Property

Transformation, optimization, and reuse of existing assets

Contents

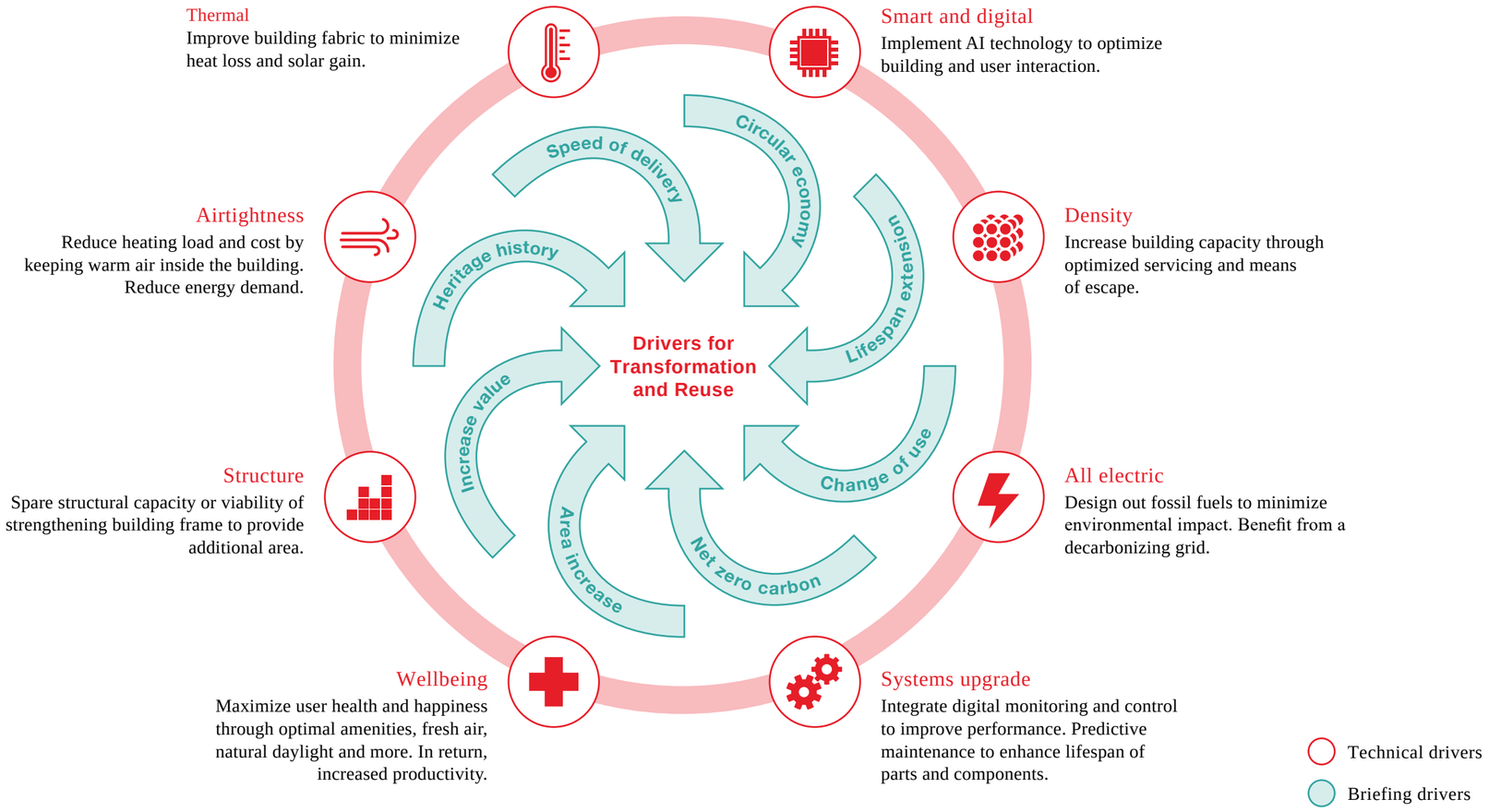
As we look toward a more sustainable and resilient future, optimizing existing buildings is becoming ever more important. In this document, Arup identifies key drivers of the evolving property market, details our capabilities, and provides examples of our work in the property sector.

Why transform?

Along with environmental benefits, transforming and reusing existing buildings often delivers greater commercial and social returns than demolishing and reconstructing. It can be more cost-effective for clients, create more characterful places for occupiers and preserve heritage value for communities.

Demolishing reusable buildings and constructing new ones in their place will only add to stresses on our planet's finite natural resources. It is time for change on a dramatic scale. With the built environment responsible for almost 40% of energy-related carbon emissions globally, we must find new ways to design and construct our cities. It is untenable that the lifespan of many modern commercial structures is close to 20 years. Given that up to 87% of today's buildings will still be occupied in 2050, we must push their performance towards zero carbon as soon as possible.

This document has been created to challenge perceptions and show that secondhand doesn't mean second-rate. Our projects demonstrate that refurbishing existing buildings contributes to the creation of exciting and dynamic places. With industry-wide collaboration and a radically different mindset, the opportunities to create great buildings while driving down carbon are limitless.



What drives the decision to retrofit?

Arup has helped owners develop multidisciplinary holistic solutions for the built environment for 75 years.

Our teams have access to colleagues with expertise in every aspect of the built environment. This allows us to rethink and reuse existing buildings in exciting and sustainable ways. Working collaboratively across Arup and with external partners, we develop tailored solutions. This includes turning aging offices into flexible workspaces, derelict yards into shopping districts, and industrial structures into homes, as well as extending the life of historic buildings and upgrading their performance. As the examples in this brochure show, all our projects are unique and informed by our experience in an ever-expanding number of disciplines and sectors. We design and adapt buildings and places, so they produce the greatest value for clients and the best experiences for people.

In today's increasingly low-carbon, digital and wellbeing focused world, our projects are underpinned by a philosophy and commitment to fulfilling client aspirations by creating smart and healthy buildings for happy and satisfied people.

Common drivers for Retrofit

Why owners face increasingly complex choices?

- Climate change
- Social media
- Wellbeing
- Technological advances
- Privacy
- External threats
- Economics
- Government mandates

Key drivers to retrofit

We offer a one-stop shop for flexible solutions and unbiased opinions that address a building's potential today and in the future.

Safety

- Fire & code
- Increased occupancy
- Rehabilitation of degrading fabric
- Security
- Façade

Resilience

- Seismic upgrades
- Flood protection
- Wind
- Wildfires
- Climate change

Wellbeing

- Well
- Fitwel
- COVID-19
- Air quality
- Accessibility to all

Viability

- Portfolio energy assessments
- Smart buildings
- Understanding and managing risk
- Reducing maintenance costs

Value

- Refurbishments
- Renewal
- Façade improvements and building re-clads
- Flexible spaces

Sustainability

- Low and zero carbon solutions
- Benchmarking
- Code driven upgrades
- Sustainability certifications

Change of use

- Adaptive reuse of existing systems
- Flexible solutions
- Fire & code analyses for change in occupancy

Tenant led improvements

- Lighting, AV & IT
- Stair connectors
- Floor loading upgrades
- Vibrations
- Retaining key staff

Offerings

As acknowledged experts in many of the fields required to successfully transform existing assets, Arup provides uniquely holistic and balanced advice that clients can trust.

Integrated design solutions

Arup combines a breadth of complementary skills and expertise to deliver solutions tailored to our client’s needs.

We offer a one-stop shop for flexible solutions and unbiased opinions that address a building’s potential today and in the future.

Managing risk

Understanding and managing the risks associated with existing assets underlines all our strategies for assessment and intervention. We help our clients make more strategic decisions by leveraging data-driven insights and the deep knowledge we've acquired delivering thousands of retrofit projects.

Our multidisciplinary expertise allowed us to transform the St Pancras renovation project into London's leading destination station. This prompted the renewal of its neighbor station King’s Cross and triggered a cascading sequence of investment in this previously inaccessible land.

Energy Optimization, Sustainability, and Decarbonization

- Energy resilience
- Low carbon solutions
- Sustainability
- Monitoring base commissioning
- Decarbonization pathways and ordinance facilitation

Transformation and Upgrades

- Adaptive reuse
- Historic preservation & conservation
- Façades and envelope renewal
- Materials & analysis
- Resilience opportunities

Workplace and Wellness

- Workplace
- Healthy buildings
- Tenant improvements
- Lighting - Circadian
- Acoustics
- Audio visual and IT smart buildings
- Security
- Code consulting
- Fire/life safety
- Pedestrian flow modeling and wayfinding

Portfolio Assessments

- Portfolio assessment
- Risk and resilience
- Risk assessment and modeling
- Portfolio energy optimization

Digital Tools

- Smart buildings
- Digital twin
- Digital site survey
- Digital master planning

Acquisitions and Technical Due Diligence

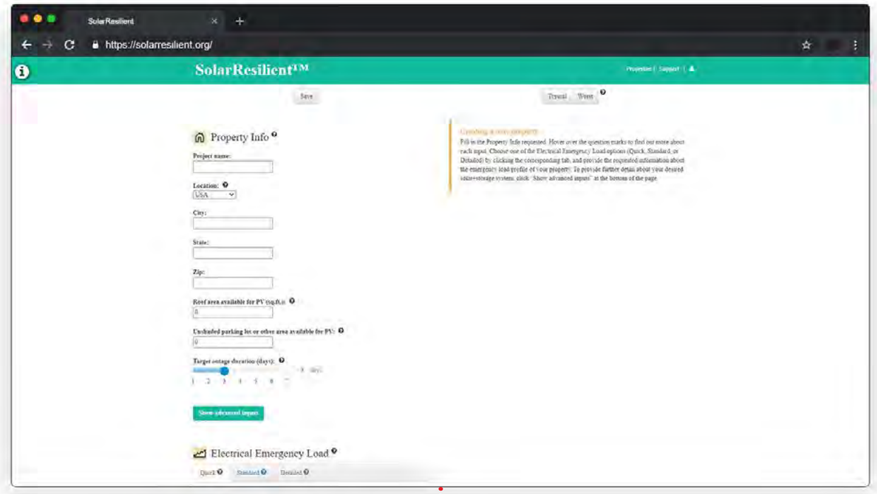
Energy resilience

In an evolving, connected, and interdependent society, secure and resilient energy provision is critical. The events that challenge consistent energy provision are proliferating and becoming more severe. There is no silver bullet when it comes to resilient energy system design. To achieve lasting energy resilience, clients must consider and respond to a wide range of technical and non-technical factors.

The Arup Energy Resilience Framework allows stakeholders working within energy systems to establish the proper context for evaluation and provision, thus enabling them to attain greater resilience.

Community Resilience with Solar + Storage

SolarResilient™ is a free online tool for building owners and operators that estimates the required rating and physical size of grid-connected photovoltaic (PV) and battery energy storage to provide power for extended periods during a large-scale grid power outage.



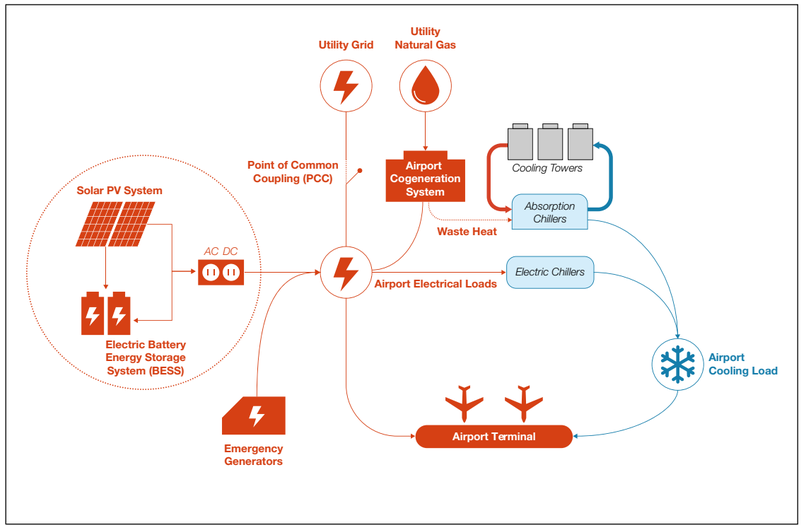
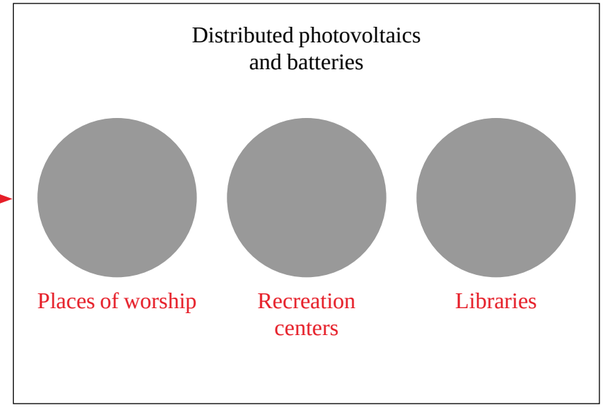


Diagram of the microgrid design for John Wayne Airport.



Risk and resilience

Resilience is fast becoming a core concern for projects across the property market. The changing climate has increased the frequency of natural disasters and created new levels of risk for property owners. To meet the demands of tomorrow, we must change the way we build, shifting the focus from meeting minimum safety requirements (the code) to building overall resilience.

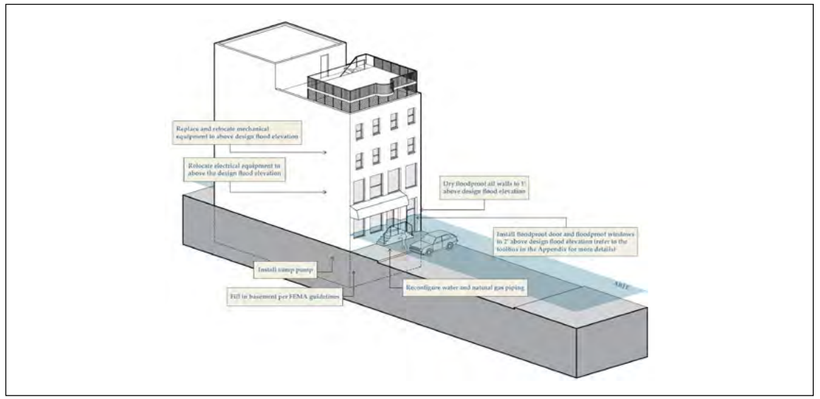
Transformation of existing property provides a perfect opportunity to introduce resilience where it was lacking before. This may happen in the context of a typical renovation, or as part of building back better after a disaster.

Whether working on a single building or a portfolio of assets, Arup works with industry-leading companies across the globe to assess their risk and build physical and organizational resilience.

Key disruptors

- Climate change
- Fluctuating market conditions
- Natural disasters
- Pandemics
- Security failures
- Seismic events
- Regulatory changes
- Resource shortages

Infrastructure improvements for MTA buildings lying in vulnerable areas included GFRC clad flood walls and a flood resistant door .



Infrastructure improvements for MTA buildings lying in vulnerable areas included GFRC clad flood walls and a flood resistant door.

Design for resilience

Resilience Shift primers

Arup leads an organization called the Resilience Shift, whose mission is to provide leadership and guidance on resilience for the built environment.

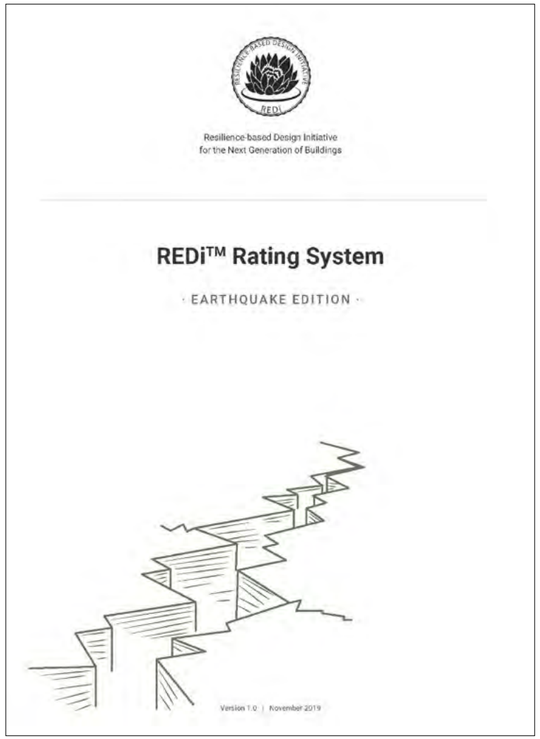
We recently led the development of a series of primers that contain valuable guidance on maximizing the resilience of infrastructure and built environment systems.

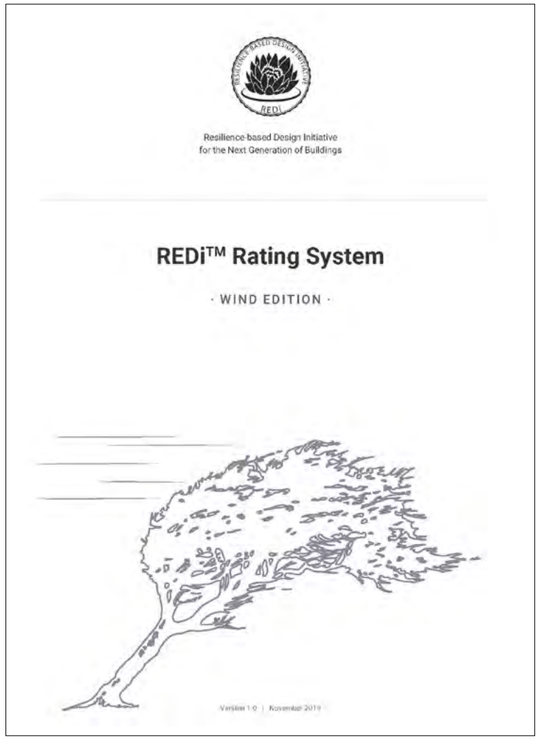
When designing for resilience, it is crucial to think beyond physical engineering and consider the organizational factors that impact risk.

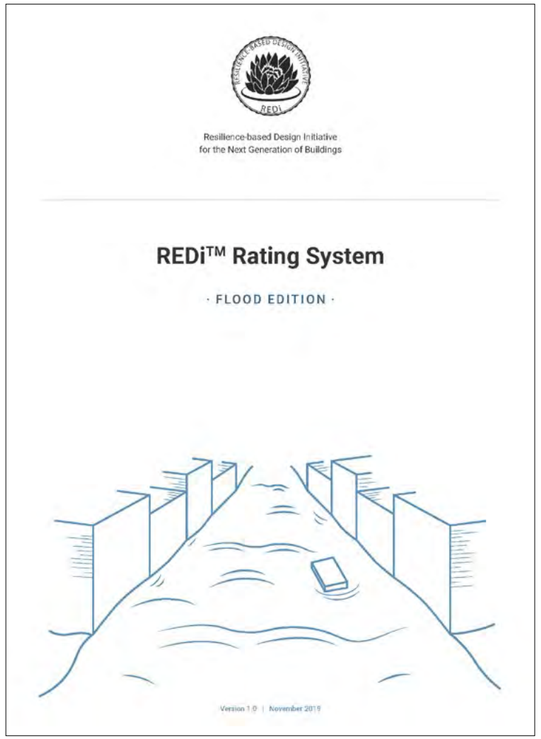
REDi rating system

Arup is authoring pioneering guides on the resilience-based design of new and existing buildings. The REDi guides for seismic, wind and flood can be used as stretch codes to enhance the resilience of a building beyond the limited levels provided by the code.

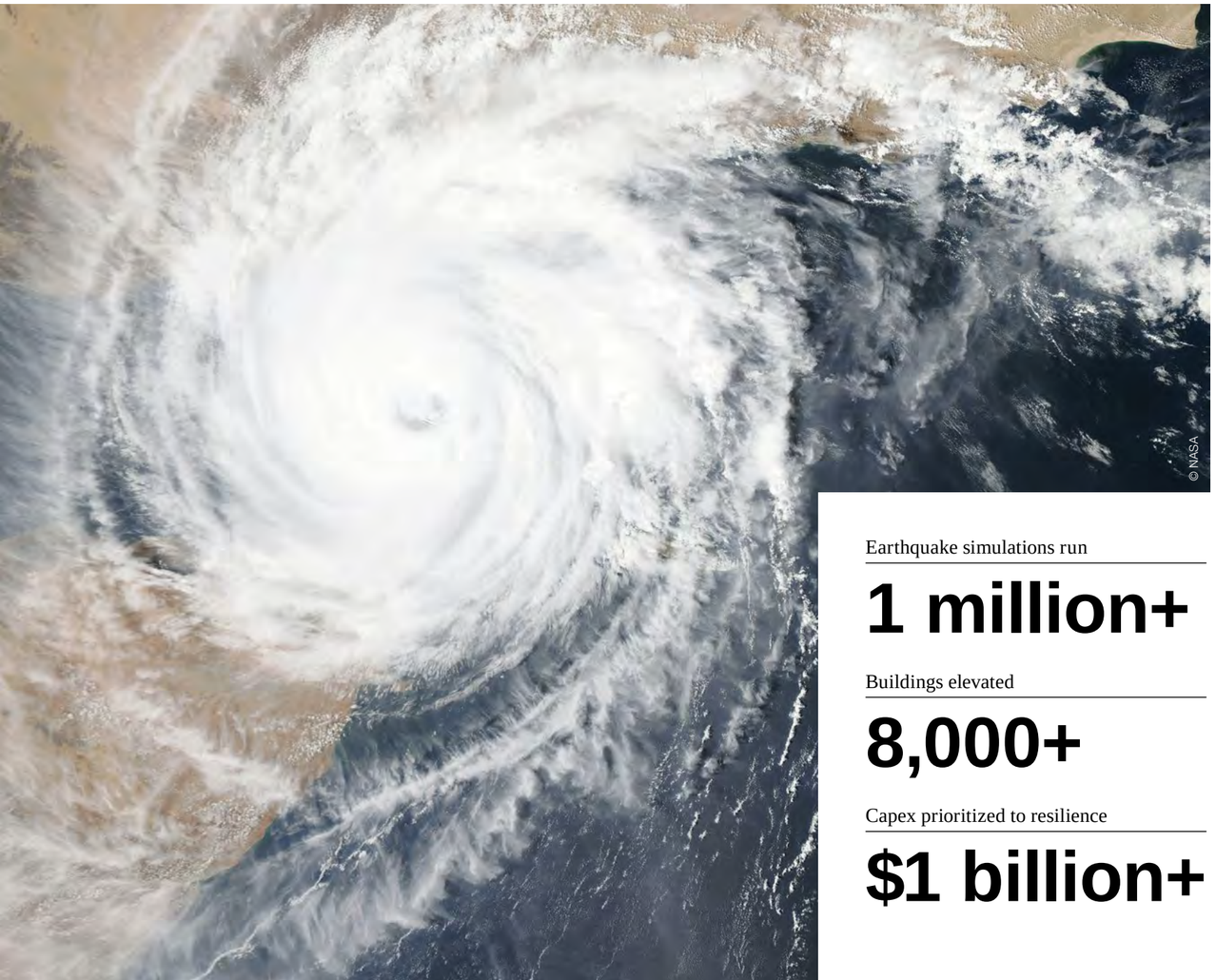
The seismic guide is already being used on projects in the US and internationally, and the flood and wind primers are soon-to-be released.







Risk Assessment and modeling



Earthquake simulations run

1 million+

Buildings elevated

8,000+

Capex prioritized to resilience

$1 billion+

Risk, not just hazard

Often we think of risk in terms of the hazard present, such as a hurricane or earthquake. In realist, risk is a combination of hazard, vulnerability, and consequence.

Arup is unique in the industry in that we combine top-quality hazard modeling with a deep understanding of building performance (vulnerability) and insight into how our clients' businesses work (consequences).

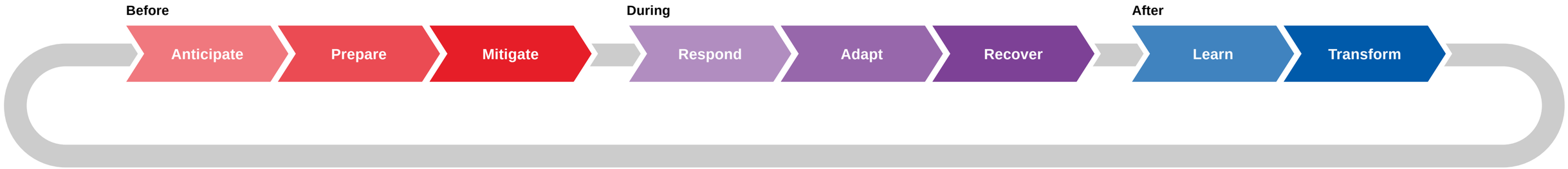
Actionable information

A study is only as useful as the results. We work with our clients to provide risk results in an actionable, interactive way tailored to their needs.

Whether we create an automated site-by-site PDF report or a web-enabled dashboard with data visualizations, Arup is always working with our clients to understand what works best for them.

Resilience cycle

The Resilience Cycle uses a 8 key resilience metrics and 48 indicators across three dimensions to measure an existing building's level of resilience.



Anticipate

- Risk assessment
- Horizon scanning
- Scenario development
- Resilience assessment
- Shock, stress and trend analysis
- Supply chain resilience assessment
- Adaptive capacity diagnostic
- Business impact assessment
- Real-time data gathering

Prepare

- Development of corporate resilience policy
- Resilience strategy development
- Leadership & team coaching
- Supply chain resilience requirements
- Digital strategy and automation
- Data management platform
- Response and recovery plans
- Testing and exercising

Mitigate

- System strengthening
- System backup
- Fail safe measures
- Team and individual coaching
- Training and exercising
- Partner and supply chain resilience building

Respond

- Incident and crisis management
- Governance and decision making
- Internal and external collaboration
- Impact mitigation

Adapt

- Financial and operational analysis
- Adaptation of processes and systems
- Adaptation of supply chains
- Adaptation of staff
- Training
- System development
- Health and wellbeing
- Capture lessons learned

Recover

- Scenario-planning for short to medium term
- Impact analysis
- Recovery/transformation plan development

Learn

- Capturing and harnessing lessons learned
- Learning program development
- Change management
- Data processing
- Brainstorming workshops
- Resilience gap assessment

Transform

- Transformational change program
- Service re-design
- Business re-design
- Update business strategy

Monitoring based commissioning (MBCx)

Status Quo

Buildings are not performing up to their potential.

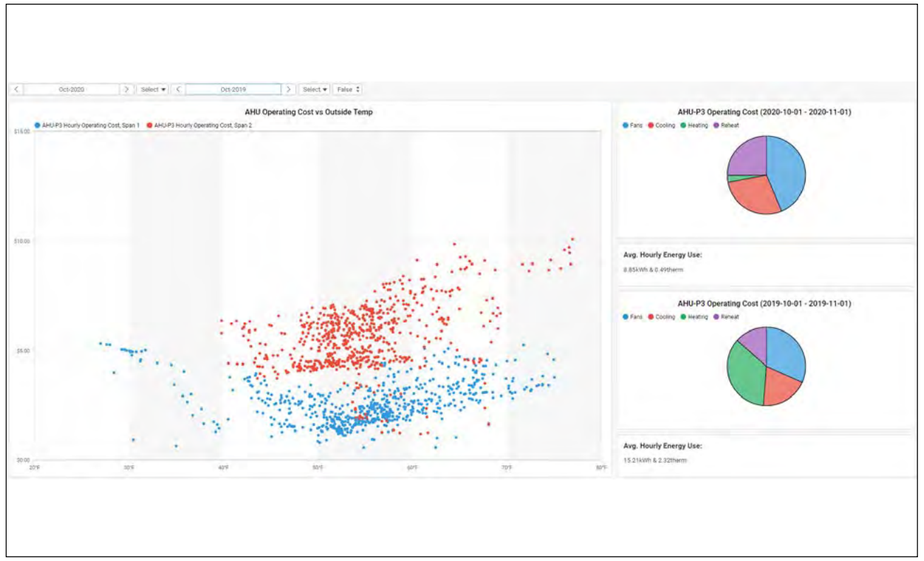
- They are being turned over to operators in a suboptimal state.
- The root causes of building deficiencies are not always readily identifiable and can be insidious.
- Building system performance is a complicated issue to measure. Typical evaluation is often based on anecdotal evidence and lacks granularity.

Approach

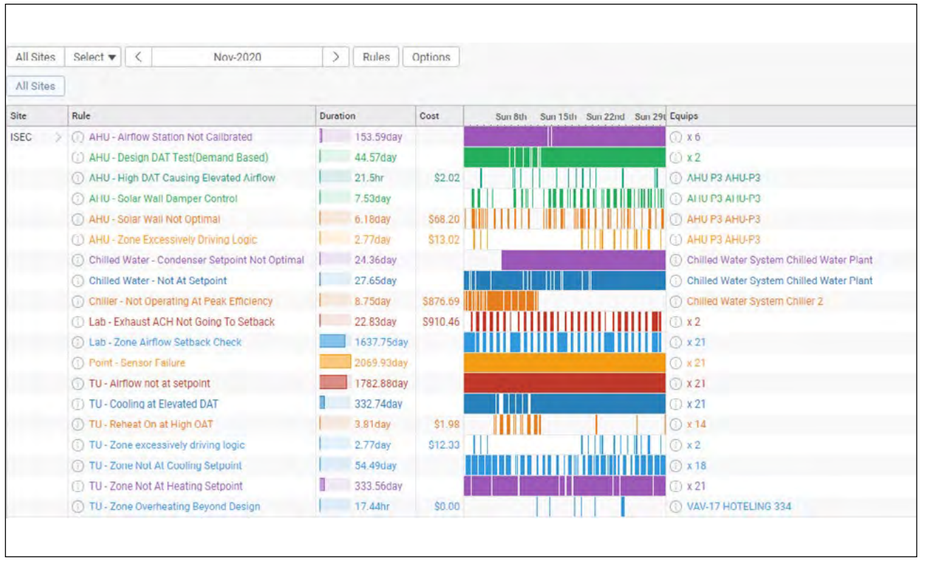
To truly improve building operations, a detailed understanding and analysis is required on both the system and subsystem level. The service is a process, not a software. Arup leverages a deep understanding of building energy consumption and operations to interpret existing data and identify opportunities for optimizations.

Realized results

Fully executed MBCx goes beyond addressing a punchlist of deficiencies. It entails follow through; management of the resolution process, verification of completion, and continuous tracking of the results.



Performance tracking of AHU energy usage before & after operational changes.



Real time detection and analysis of system deficiencies.

Digital master planning

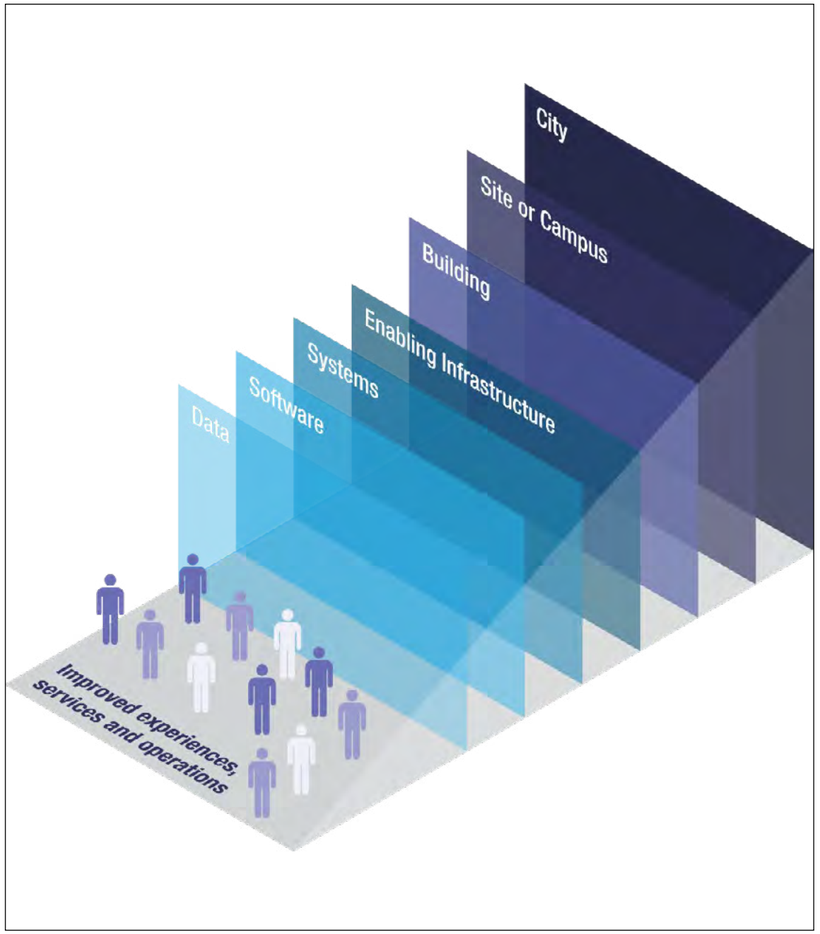
The built environment is rapidly evolving to integrate digital along many dimensions. Digital tools, processes, and approaches are leveraging data in new and intriguing ways and changing the way buildings and portfolios are planned, designed, implemented, and operated. By defining the outcomes and experiences expected from such digital platforms, Arup is pushing the boundaries of how data is created, captured, integrated, and visualized.

Through direct experience on many development projects, we have crafted a custom framework to help our clients engage with what can be a complex topic. By working at the outcomes and infrastructure levels in parallel, our approach maps with the reality of how buildings are planned, implemented and operated.

Arup helped a client implement a site-wide network that harvested data from their building's WiFi system, Twitter, public databases, and other sources to create a dynamic visual display for a live event.

Dynamic estimation of people on site using a WiFi "heat map."

Arup developed a site-wide network that pulled data from social media, public databases, and other sources and was used to inform the visualization of information on a custom display.



Arup's Digital Master Planning Framework

Smart buildings

Direction

The built environment has gradually evolved towards intelligence.

- Today's building management systems are monitoring and managing beyond temperature control.
- Traditional infrastructure systems increasingly share a common communications network that facilitates access to, and activation of, building data.
- “PropTech” is introducing sophisticated tools into the market to enhance operations and occupant experiences.

Approach

To achieve building intelligence, Arup begins by working with clients to define objectives and develop a prioritized and budgeted roadmap to achieving them. Phased implementation allows clients to realize benefits quickly while not overwhelming their teams or overlooking CapEx and OpEx realities.

Goals

Smart buildings can:

- Increase asset value
- Reduce OpEx
- Provide improved occupant experience
- Reduce carbon footprint

Digital twin

Definition

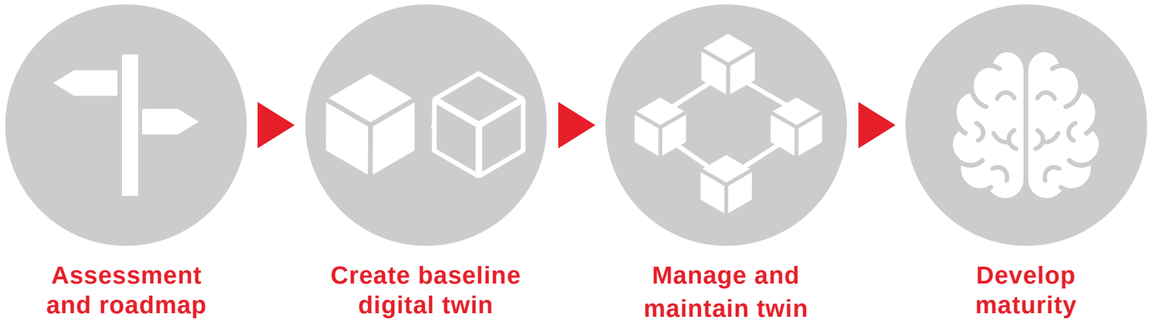
A digital twin is a realistic digital representation of an asset, process, or system in the built or natural environment, produced at a level of detail suitable to its stated purpose or use-case.

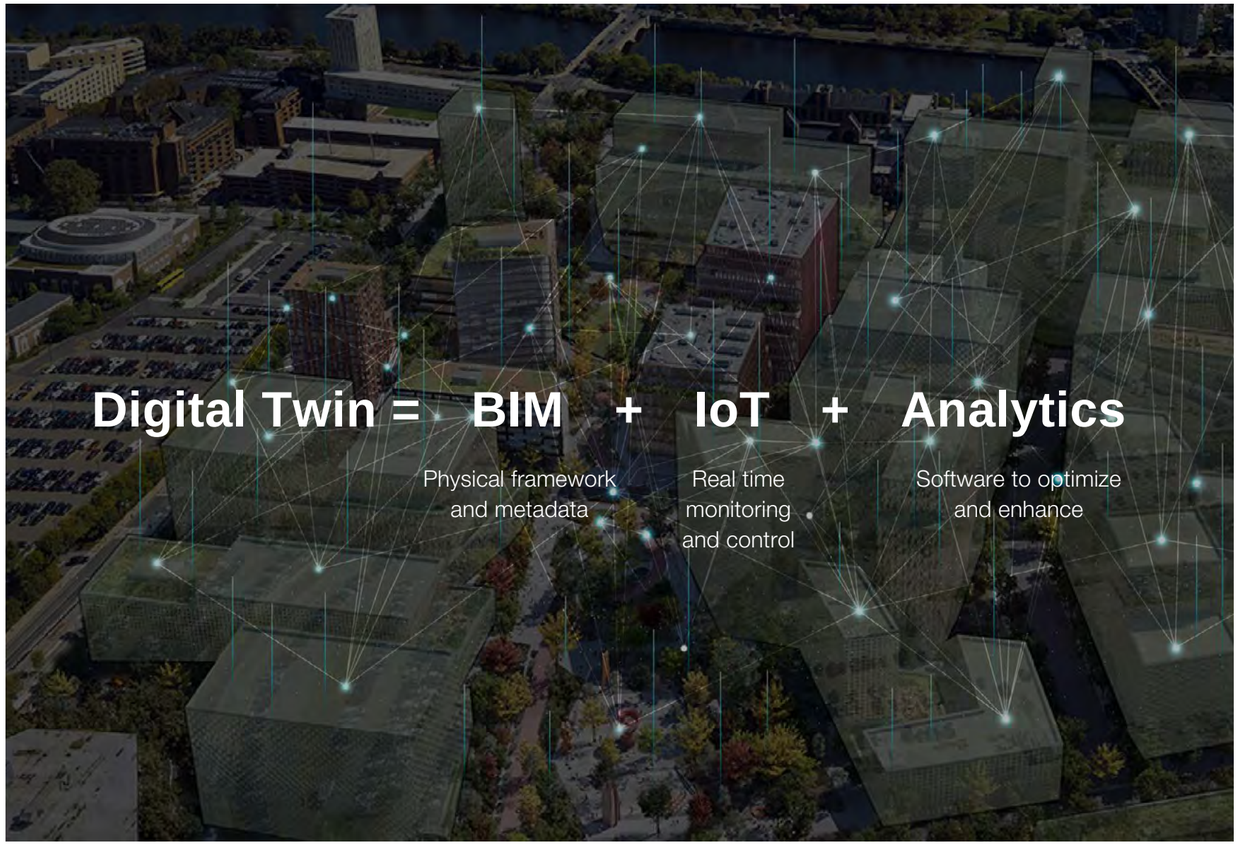
Unlike less sophisticated digital models, a digital twin can be leveraged to analyze asset data (generated by internal building systems or pulled from elsewhere) and used to dynamically enhance the performance of a building, system, or process.

Potential

In addition to streamlining ongoing monitoring, digital twins can leverage artificial intelligence, machine learning, and consolidated data to autonomously optimize building operations and the occupant experience.

Process





Healthy buildings

As we return to public life, there is a greater need to know the health status of the public places we occupy. Accessing real-time information about indoor environmental conditions can provide instill a sense of confidence and speed the return of a comfortable and productive work environment.

Our team can advise on the steps necessary to become WELL or Fitwel certified and help improve health and wellness conditions by recommending measures to enhance air quality, material selection, water quality, circadian lighting, daylighting, and sound and vibration levels.

We can also advise on Internet of things (IoT) and building management systems (BMS) deployments to monitor indoor environmental quality, occupancy density and cleaning status--three categories of health and wellness data valuable to both owners and occupants. We can recommend several systems that sense indoor air quality, including levels of CO_2 as a proxy for fresh air, particulate matter, and volatile organic compounds and other wellness data streams.

We can recommend best practices for making this data available to tenants. At the right is an example of a “building dashboard” that reads out indoor environmental quality, occupancy and cleaning status data on a dynamic display that can also carry other information relevant to occupants.

Install a building dashboard at the threshold of commercial office spaces to offer users real-time data on IEQ and health status.

Resilience opportunities

Renovation provides a key opportunity to improve a building's resilience. A wide range of structural and physical modifications can contribute to resilience, from improving a building’s existing envelope to adding a back-up generator to relocating mechanical systems from the basement.

Operational measures are also important, and Arup can work with you to improve your business continuity and emergency response planning so that your organization is prepared for shocks and stressors.

Structural retrofit to the exterior of building limits interior architectural impact.

Retrofit of seismic dampers reduces damage from earthquake and provides opportunities to minimize disruption to the office floor plate.

Retrofitting temporary or permanent hurricane shudders to prevent building envelope penetration in extreme winds.

Establish a flood perimeter defense while limiting disruption to everyday operation by combining deployable barriers and permanent infrastructure.

To ensure business continuity, it is essential to safeguard mechanical, electrical, and backup systems. Renovations provide an opportunity to install these systems in locations with a low risk of flooding.

Adaptive reuse

Transforming existing spaces to meet changing needs provides an opportunity to extend a building’s useful life, while providing unique spaces that have more value than comparable new-build solutions.

These projects offer unique challenges that make creative design crucial. Along with environmental benefits, transforming and reusing existing buildings often delivers greater commercial and social returns than demolishing and reconstructing. It can be far more cost-effective for clients, create more characterful places for occupiers, and preserve heritage value for communities.

©Berlin Rosen

The award-winning conversion of a coal burning power plant into Class A office space was achieved by rationalizing the plant's existing floor plates, which doubled the lettable space while preserving the building's unique character.

©Maconochie

The former TWA Terminal at JFK International Airport was successfully transformed into a 500-room hotel. The development includes a below-grade conference center that supports a super-constellation jet, which now serves as an exclusive cocktail bar.

©Hufton+Crow

At Coal Drops Yard in King’s Cross England, Arup helped turn three largely derelict heritage buildings into a popular shopping and dining district. Victorian brick viaducts are now home to modern retail brands and restaurants, with space in-between for events, art installations, and markets.

Historic preservation & conservation

Valuable cultural assets, like landmarked buildings, require creative, context-appropriate restoration solutions. Arup frequently leads specialist preservation teams, negotiates with regulatory bodies, and delivers sensitive restoration schemes that preserve character while enhancing efficiency and value.

Dealing with regulatory authorities

Arup regularly coordinates and leads discussions with SHPO and Local AHJ's, such as the NYC Landmarks Preservation Commission, and coordinates with conservation specialists to help clients leverage Historic Preservation tax credits for their projects.

We develop designs in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties while working in the US, or alternatively use the Standards and Guidelines for the Conservation of Historic Places in Canada.

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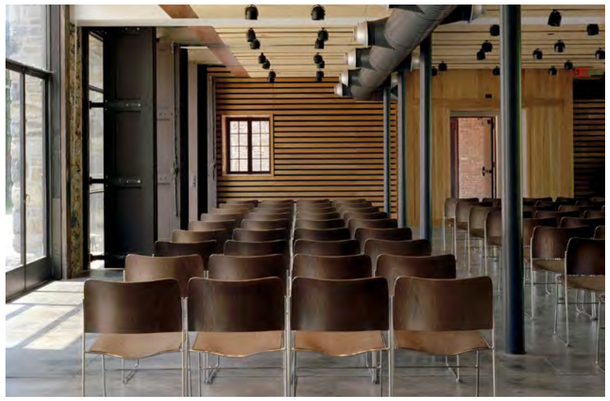
The restoration of St. Pancras Hotel in London integrated modern MEP systems without compromising the historic structure's existing interiors.



©Michael Moran Photography Inc

A change program for the interior of the Rockefeller Stone Barns Center left its historic facade largely unaltered

© Wade Zimmerman

For the Corbin Building renovation in New York City, Arup developed repair techniques that allowed for most elements of the building to remain in place during the restoration of its exterior brickwork, stonework, and cast-iron façade. By retaining a watertight shell, restoration was completed ahead of schedule at a reduced cost.

Materials & analysis

Existing buildings projects demand a thorough understanding of existing constraints, and the materials used during construction are among the most important.

Arup employ in-house specialists who can advise clients on a wide range of materials including:

- Concrete
- Steel and early iron
- Brickwork
- Stonework
- Glass
- Terracotta
- Timber

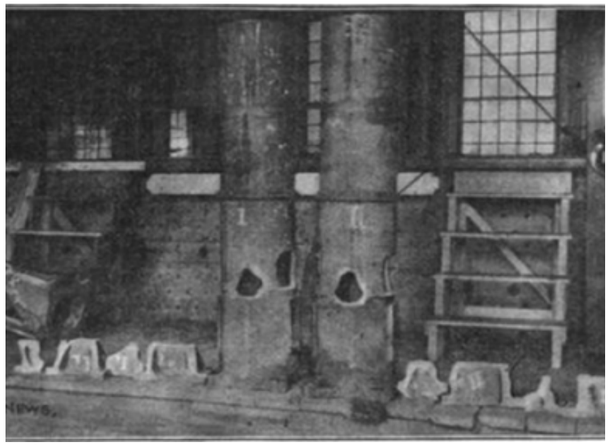
Where needed, we design and supervise field investigations to mitigate risk and maximize efficiency.

Analysis

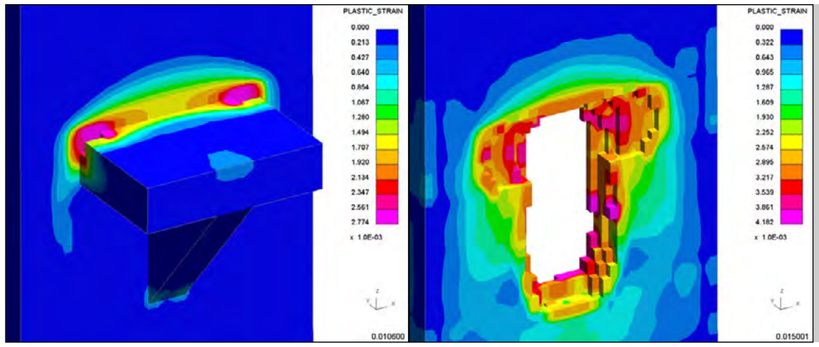
A thorough understanding of materials allows us to design complementary interventions.

Arup uses in-house Oasys software together with LS-DYNA FE models where appropriate to predict the behavior of existing systems.

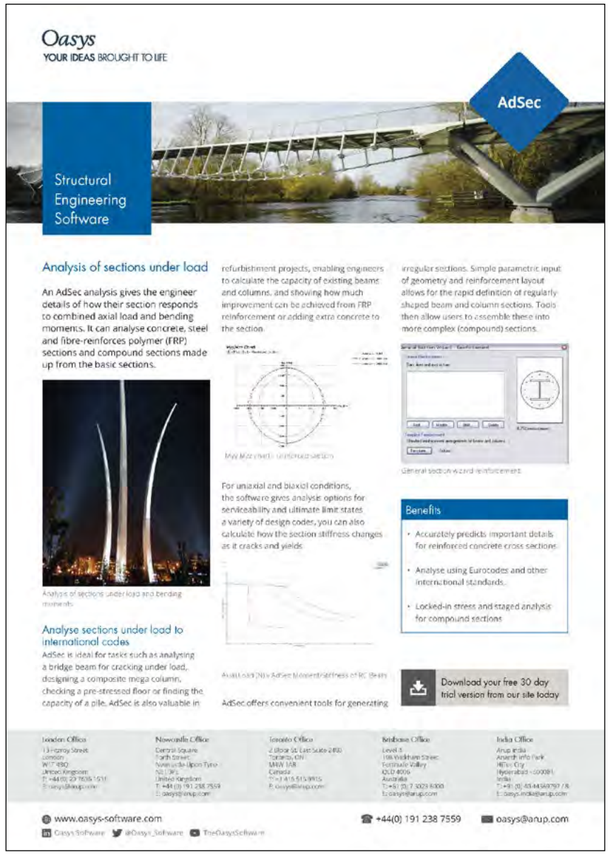
In-situ materials testing of concrete to establish strength and material properties allows appropriate solutions to be developed.



Modeling cast-iron column corbels helped avoid expensive upgrades for the Fulton Center Station.



LS DYNA analysis of cast-iron connection details in historic frame to justify increased floor loadings. The analysis was able to closely replicate the observed failure mechanism documented by historical sources.



Oasys AdSec Software allows for modeling of complex compound sections combining new and existing materials to achieve efficient design.

Code consulting

How will the work be classified by code and what are the design and cost impacts?

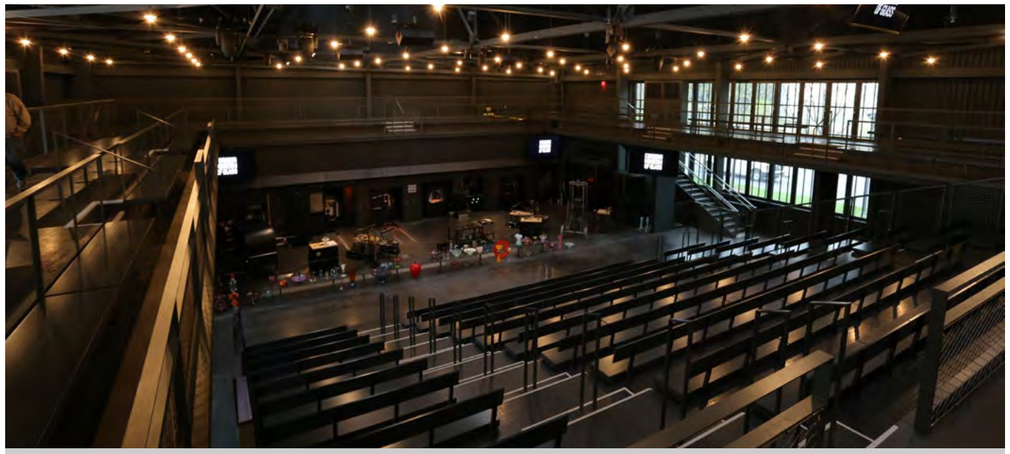
How can I maximize the potential of a space while still meeting code?

Do existing fire protection and egress systems meet code or will they require major upgrades or replacements?

Arup has institutional knowledge of historical codes and their lineage.

We are active in code development, working with various cities nationally and internationally to model codes and standards. Our people bring these insights to clients and to local authorities to guide approvals.

As part of our retrofit offering, Arup uses in-house Oasys software, together with LS-DYNA FE models where appropriate, to predict the behavior of existing systems.



Code analysis for the conversion of the Stueben Glass Factory into a performance venue at the Corning Museum of Glass. Analysis preserved the existing steel truss roof, the non-rated construction type, and increased the occupancy, including adding a new mezzanine that allowed the space to connect with the adjacent museum.

Acquisition due diligence existing conditions assessment and code/ egress analysis for Webster Hall. Work allowed for increased occupancy and identified and prioritized major upgrades.

©Scott Frances/Otto

©Joseph Reed

Code consultation and performance-based approach for use of plastics in lobby renovation and repositioning at Park Avenue Plaza.

©Starbucks

Code consultation and approvals to enable use of innovated ceiling system in Starbucks Roastery NYC.

Performance-based design for fire/life safety

Did you know the code allows for alternate methods and performance-based design?

This is also true for alterations, additions, conversions, and gut renovations of existing buildings.

Performance-based design helps building owners and developers avoid certain major upgrades or alterations to items that are non-conforming by offsetting them with fire/life safety enhancements and using engineering analysis to demonstrate an equally safe solution to the prescriptive requirements of the codes.

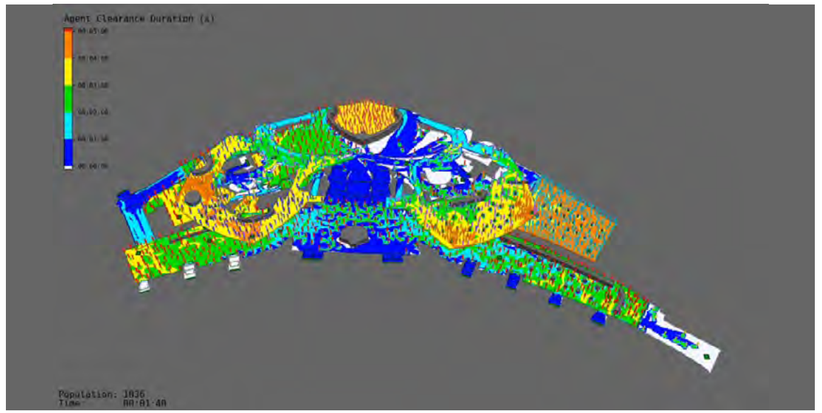
Arup leverages our combination of code knowledge and first principles to address all types of non-compliances. For major items, we can also use computational methods to model fire effects, evacuation, and structural response in a fire. As a multi-disciplinary firm with a deep bench of experts, we can call upon different disciplines to meet the unique needs of each project.

©Berlin Rosen

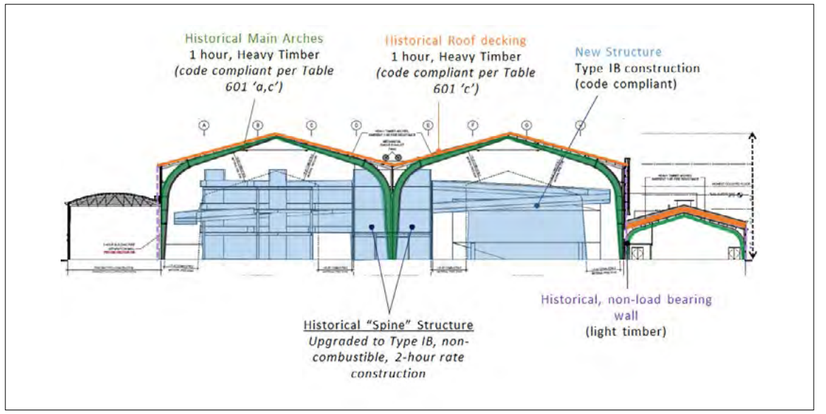
The existing TWA Flight Center had non-conforming stair treads and guard rails, extended travel distance an no sprinklers at the main roof.

©Google

A performance-based fire engineering approach was used when converting the historic Spruce Goose hanger into offices.



A performance-based approach was used to address existing non-confirming conditions and change of occupancy for the TWA Hotel. Evacuation modeling is shown here.



A fire engineered approach to preserving the heavy timber roof and arches of the Spruce Goose.

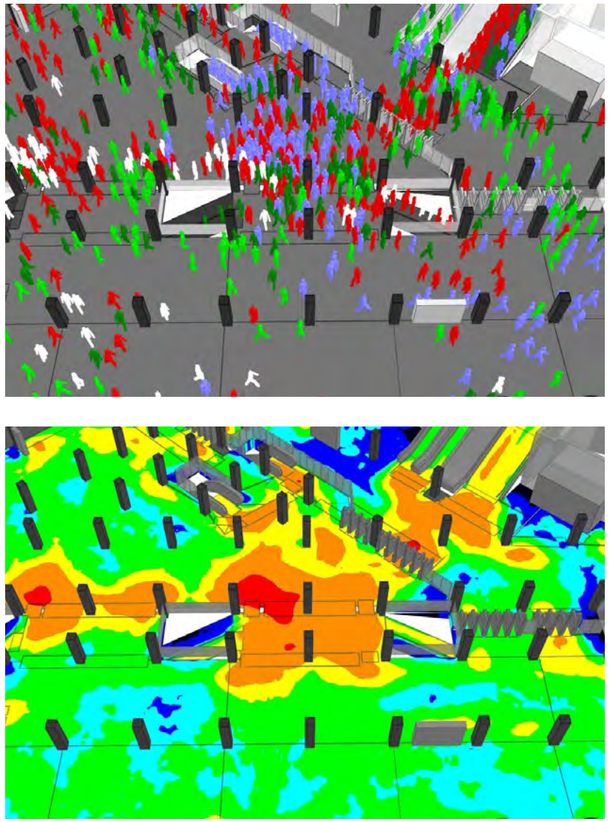
Pedestrian modeling and wayfinding

Arup offers a complete range of wayfinding, pedestrian planning, and modeling services to help our clients solve problems in complex environments.

Our work on existing buildings and facilities spans from high occupancy spaces, such as stadiums, stations, airports, major events spaces and building lobbies to multi-modal transportation hubs, urban networks,and open spaces. We use our approach to inform the design of expansions and renovations, as well as evaluate operations, staffing levels, security, and concessions/ dining. Our wayfinding designers can develop complete signage and information systems to improve the user experience.

Our approaches include:

- On-site data collection and observation
- Diagramming, spreadsheet models, and flow analysis
- MassMotion, a 3D microsimulation pedestrian modeling program made by Oasys, Arup's in-house software development team
- Wayfinding audits and strategy development
- Signage design



Arup developed a MassMotion pedestrian model of the Grand Central–42nd Street Station mezzanine to demonstrate performance of upgrades to the station. Top, agents in the model simulating pedestrian movement. Below, Level of Service map showing areas of congestion.

For the Library of Congress, Arup helped develop a visitor experience master plan, providing strategies to simplify the visitor experience in the historic Jefferson Building.

Digital site survey

Current constraints are curtailing travel and preventing or restricting access to certain sites, making the remote inspection and visualization of assets and projects a huge advantage. Arup deploys mobile inspection and data collection applications in the field to digitize workflow and enable the collection of rich data on conditions, including panoramic images and videos. These are collected at the point of inspection and automatically geolocated to the correct location on site. These consistent workstreams can be undertaken by the right people on the site, without having to send experts or specialists from far away, thus reducing travel time and expense.

We can conduct digital inspections and data capture surveys of assets quickly, accurately, and consistently, regardless of how complicated. Captured data is securely synchronized via the cloud on achieving connectivity, enabling rapid collaboration with other interested parties. Decoupling data collection from data assessment allows multiple parties to conduct inspections and surveys following a consistent workflow and upload the captured data into a central repository. The use of remote inspectors linked in real time to our specialists also accelerates their technical development.

Arup Inspect 3D & Fulcrum

These mobile applications streamline the collection of data from the field, making it easier to combine GIS information, field conditions, and photographs in one convenient location.

360 cameras

The 360 cameras used by Arup capture a complete image of the surroundings. The image allows the viewer to “stand in one place” and rotate their head in all directions. It can also be easily viewed and shared on mobile devices.

3D photography scanners (Matterport, Ricoh Theta)

These tools utilize 360 cameras to create 3D digital model renderings of existing structures, allowing clients and designers to experience them digitally in an immersive setting.

LiDAR

LiDAR stands for light detection and ranging. It is a method of surveying that utilizes light and measures its reflection to quantify distances. The information is used to generate point clouds that support the creation of accurate 3D models, including imagery.

Digital survey

Arup selects survey methods that maximize value for our clients.

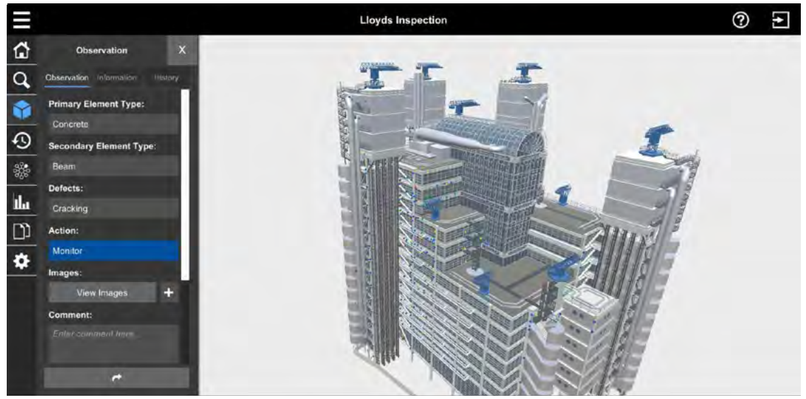
Tools and processes

- LiDAR
- 360° photography
- Photogrammetry
- Arup Inspect 3D
- Mobile apps to collect & share geotagged assessment data

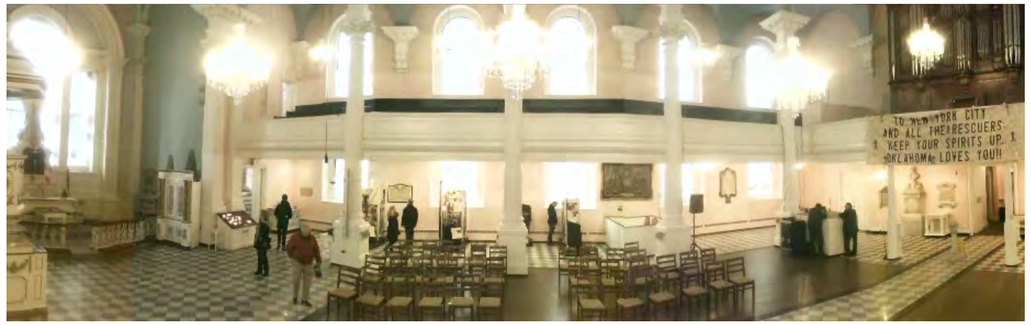
Benefits and added value

- Clear, organized, structured data
- Availability of current information to all project team participants
- Customized solutions to meet clients' project goals

Arup LiDAR scanned the Athenahealth building in Boston to verify construction fitout accuracy.



Arup Inspect 3D – Tablet app developed by Arup to streamline site inspection and data capture.



For St Paul’s Chapel in New York City, Arup used Matterport to scan historic preservation work and building improvements.

Acquisition technical due diligence & peer reviews

Arup's depth of experience across a broad range of disciplines can be leveraged to assist property investors in the assessment of a potential asset. Our range of services and detailed knowledge of local markets throughout the Americas allows us to assist global property portfolio investors in assessing risk and identify opportunities throughout the region.

Our technical advisory and peer review offering includes:

- Investor technical due diligence review to identify risks to feasibility, cost, and schedule
- Code-required peer reviews
- Value-engineering assessments
- Forensic assessments for projects that have experienced issues during or after construction
- Existing building investigations and rapid assessments
- Site assessments

Arup provided structural engineering technical due diligence and value engineering review to support Mitsui's $1B investment in Related's 55 Hudson Yards project in New York City.

Arup provided structural, wind, and geotechnical engineering peer review and forensics analysis to assess Fortis Property Group's tower under construction at 161 Maiden Lane in New York City.

Arup provided structural & wind value engineering alternative options development for Gemdale and Madison Equities' proposed tower at 45 Broad Street in New York City.

Acquisition technical due diligence & peer reviews

Arup provided structural engineering technical due diligence and site vibration assessment to determine the impacts to project feasibility of the traffic tunnel running under the site of Related Beal's proposed mixed-use development on the Gillette Channel-side site in Boston.

Arup provided structural, geotechnical, and seismic engineering technical due diligence and site assessment advise to help Mitsui Fudosan assess risks and opportunities associated with their planned investment into Tishman Speyer's Mission Rock Development in San Francisco. The project sits on difficult soil in a high seismic environment.

Façades

Existing property repositioning

Arup offers advice on all aspects of existing building façades, including related reviews and assessments of issues and failures. Our aim is to help clients realize their objectives for aesthetics, performance, durability, quality, cost, and schedule.

Arup offers the following range of façade engineering services:

- Acoustic performance assessments
- Building envelope & roofing system design
- Condensation mitigation
- Re-clad and over-clad consultancy
- Daylight management and glare control
- Energy modeling
- Existing condition assessments
- Forensics and remedial
- Glass and special structures
- Security and blast
- Thermal performance assessments
- Waterproofing

©MdeAS Architects

The repositioning of this historic tower's lobby space created a transparent and welcoming entry for the tenants and emphasized the modernization of the building while providing comfort and maintaining the US Green Building Council LEED EB certification.

©SOTAWALL

The re-cladding of this iconic 49-story tower from the 1950s allowed for deeper daylight penetration into workspaces, improving the wellbeing of building occupants. In addition, improvements to the façade and the performance of BMS systems yielded approximately 40% in energy savings and positioned the building to compete with newer high-rise offices.

Tenant improvements

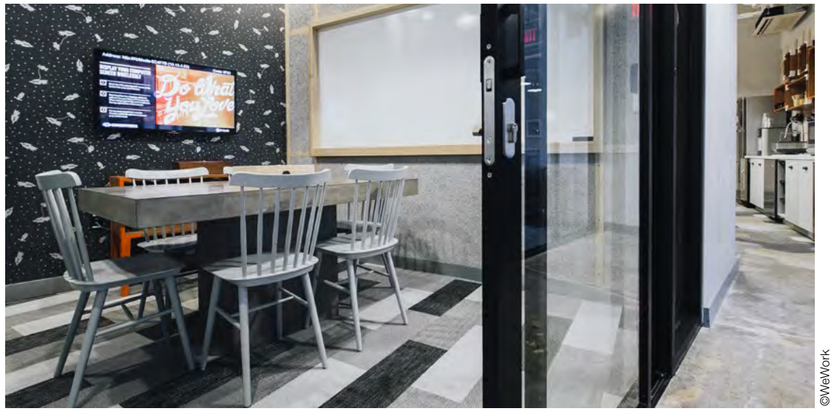
Designed spaces for today’s workplace needs

The most successful office spaces make the productivity and wellbeing of building users their central focus. The office spaces Arup designs must meet the needs of today’s occupants and current legislation. They also need to be ready to adapt to evolving requirements.

We support our clients–whether developers, owners, or occupiers–in creating workplaces that reflect their unique culture. A well-designed office space can reinforce the ethos of an organization.

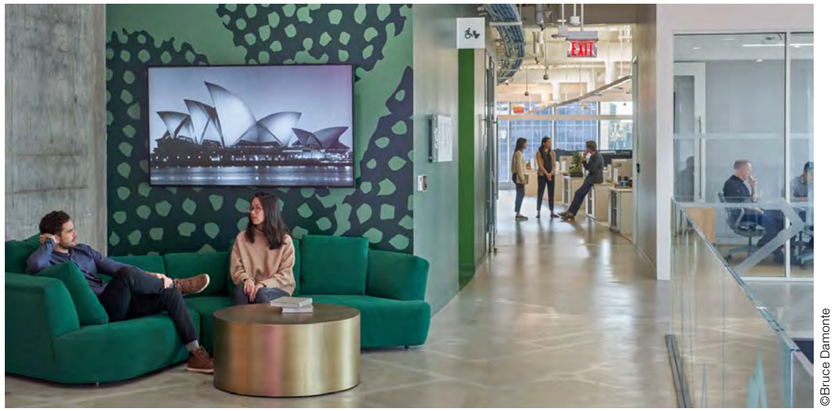
Technology and lifestyle changes mean that people are communicating, collaborating, and working in new ways. This shift has created an opportunity for companies to rearrange and optimize their offices to fit new work patterns, incorporating more shared areas for flexible use.

We work with our clients to assist them throughout all phases of a tenant process, from site selection and design/fit-out to move-in and facility operations.



©WeWork

WeWork Office, 51 Melcher, Boston MA



©Bruce Damonte

Arup Office, 900 Wilshire Blvd, Los Angeles, CA

©WeWork

WeWork Office, 51 Melcher, Boston MA

©Bruce Damonte

Arup Office, 900 Wilshire Blvd, Los Angeles, CA

Tenant improvements

Holistic Design Solutions

With offices in cities around the world, Arup combines global reach with local knowledge. Our multidisciplinary expertise fosters holistic thinking and helps clients optimize the design process and address any challenges that arise throughout the life cycle of a project.

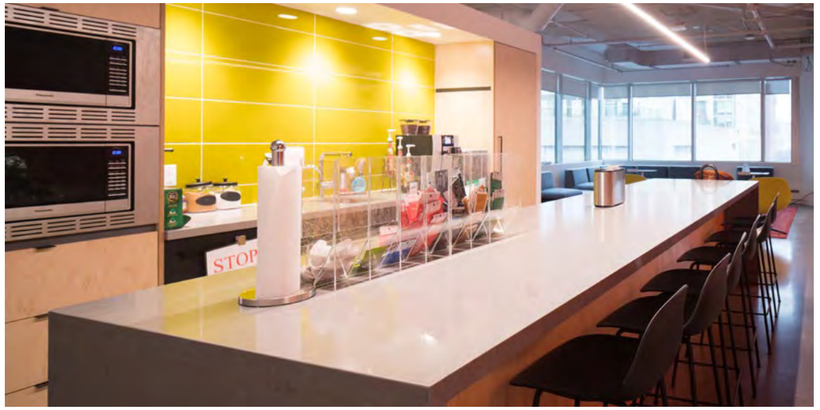
Understanding the power behind a client brand

To communicate a cohesive brand, it's essential that visual and operational components are consistent throughout the entire corporate portfolio. We support organizations in developing design guidelines and standards for MEP, acoustical, A/V, IT, security, and lighting design to ensure global consistency.

WeWork Office, 500 Yale, Seattle, WA

Arup Office, 121 Bloor St, Toronto, Canada

WeWork Office, 500 Yale, Seattle, WA



Arup Office, 121 Bloor St, Toronto, Canada

ARUP

Workplace

Public health research is linking health and productivity to the built environment.

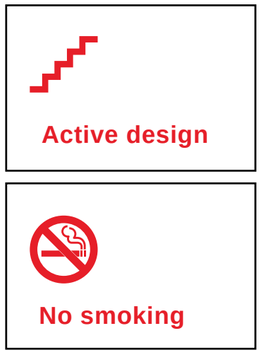
> “In the U.S., 87% of people do not meet fruit intake recommendations.”
>
> CDC

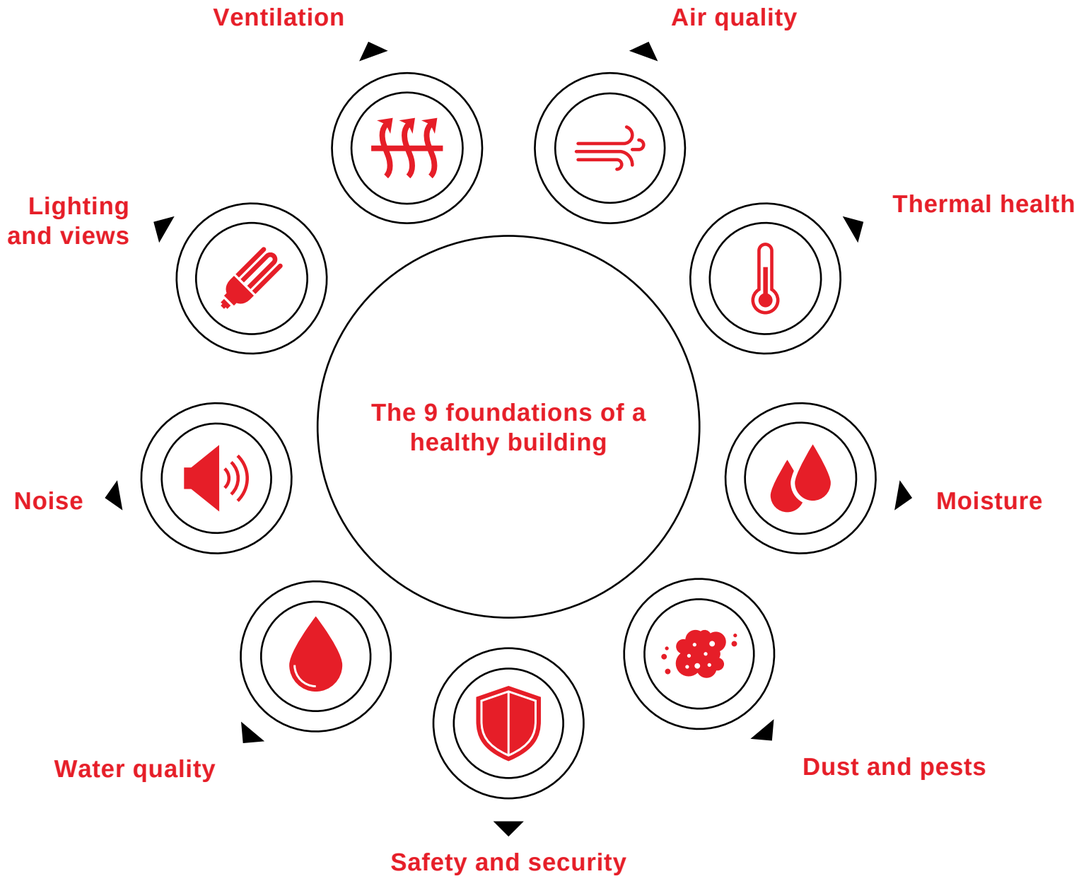
> “Your social & physical environment is the largest determinant of your health.”
>
> CDC

> “People with sedentary jobs have 2x risk of cardiovascular disease as people with standing jobs.”
>
> BMJ

> “Workers exposed to higher noise in office environments have higher adrenaline.”
>
> Cornell

> “Disengaged employees cost the U.S. between $450-550B annually.”
>
> Gallup





Workplace

The definition of a ‘green building’ is evolving. Today's green building must be both environmentally friendly and healthy for occupants.

Arup Boston Office

- Competed: December 2016
- Size: 16,000 ft^2
- Certifications: WELL Gold & Fitwel 3-star
- LEED-CI v4 Platinum

Strategies

- Circadian lighting design to change color temperature and intensity throughout the day with 0.67 W/sf
- 100% sit/stand workstations
- Smaller individual workstations and more collaborative/ adaptable spaces
- 50% materials by cost have transparency declarations & WELL Feature 25 Toxic Material Reduction was achieved
- Ongoing air quality monitoring
- 75% workstations are within 25’ of façade

> “Productivity benefits of $6,500 per person per year with green buildings.”
>
> Harvard Business Review

> “65% of staff said that their productivity is positively impacted by the office's environmental conditions (comfort, lighting, air quality), compared to 8% in our old office...”
>
> 2018 Arup Boston office survey

Arup’s Boston office serves as a living laboratory. We used wellbeing assessments to help quantify the impact of health and wellbeing strategies in the workplace.

Portfolio assessment

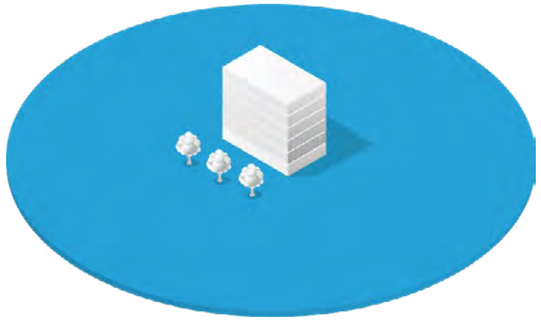
We work across scales

Arup helps clients make more informed infrastructure and operational decisions and prioritize those investments that maximize return on investment and help position organizations to thrive in a changing world.

Portfolio Assessment

We have advised large-scale portfolio owners in both the public and private sector on how to address physical, operational, and economic risks and recommended solutions at the asset level and across systems, cities, and global portfolios. With a breadth of engineering, consulting, digital, and data service offerings, Arup provides clients with key insights as a project moves from exposure data to implications to solutions. We have experience advising at the policy, social,and economic level and can translate that advice into actionable strategies for the built environment.

Arup works with businesses to build resilience in a variety of ways, from considering how climate change affects business continuity planning to assessing how urban transportation and infrastructure systems might impact resilience. We also understand the larger social implications of climate risk and can work with clients to build resilience by adopting Corporate Social Responsibility (CSR) and Environmental Social and Governance (ESG) standards that will keep them thriving well into the future.



Building-level

Campus-level

Portfolio-level

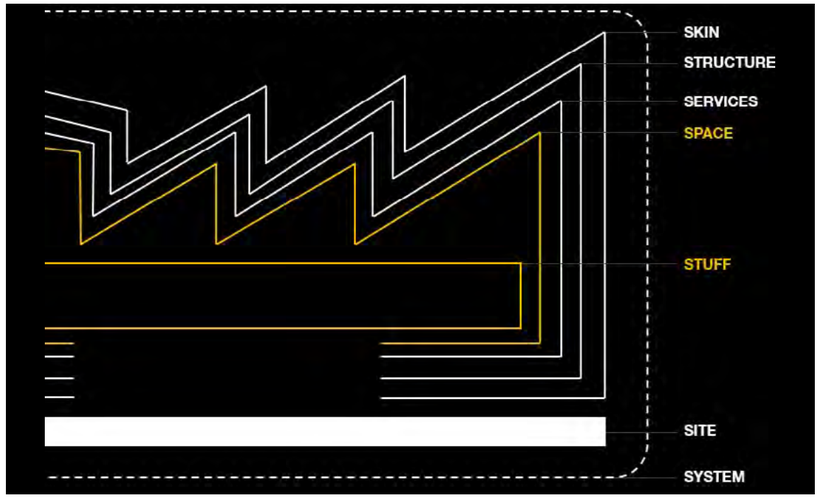
Integrating sustainability

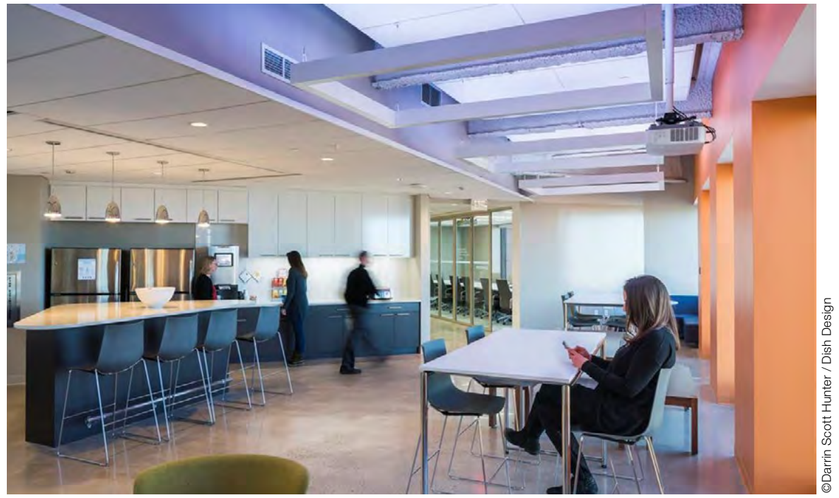
Sustainable building is becoming increasingly important as more tenants and building occupiers seek and even demand sustainable buildings to run their operations and satisfy their shareholders. At the same time, increased awareness of the impacts of air quality, light, and materials on our wellbeing is leading to growing demand for healthy buildings.

Arup has been at the forefront of sustainable building design for decades and has helped clients of all kinds retrofit buildings to unlock new value and increase their sustainability performance. We look at existing buildings holistically—developing a vision for the building, analyzing which interventions make the most sense, and devising tailored retrofit strategies.

We also have extensive experience with all the relevant certifications, including LEED, WELL, and Fitwel, and have applied them to the renovation of interior spaces and entire buildings. Circular economy principles are also central to our work and we work with clients to identify how their buildings can close the loop in generating waste and uncover hidden economic benefits.

- Planning advice
- Masterplanning
- Daylight analysis
- Environmental impact assessment
- Replica luminaire design
- Bespoke luminaire design
- App development
- External lighting

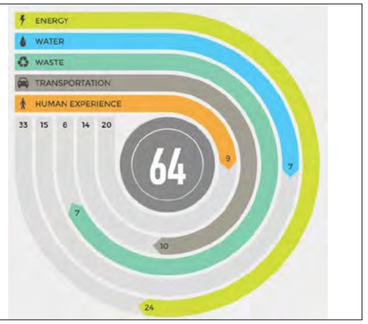




©Darrin Scott Hunter / Dish Design

INTERNATIONAL WELL BUILDING INSTITUTE™

LEED v4.1

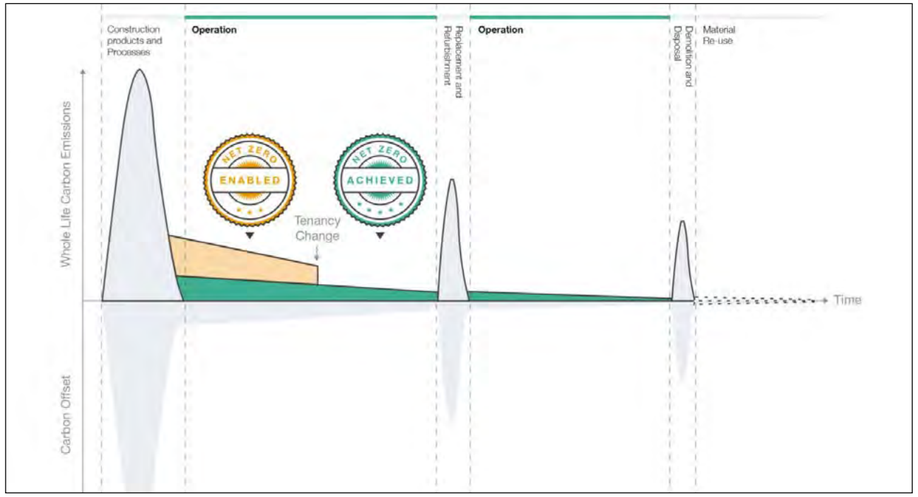


fitwel

Low carbon solutions

Buildings generate nearly 40% of global greenhouse gas emissions. Eighty percent of existing buildings will still be here in 50 years. To significantly reduce our climate impact, we need to radically rethink existing buildings, refurbishing them so they use less energy and can be supplied from cleaner energy sources.

Arup has developed an approach that helps building owners identify opportunities to lower energy and carbon emissions. With extensive experience working on different building types in climate zones throughout the world, Arup is equipped to develop targeted low carbon solutions in a rapidly changing regulatory and code landscape. Our services can be applied to all the stages of the building life cycle and are informed by life cycle costing analyses.



A whole life cycle approach for net zero requires the right design brief, deliberate sequencing of interventions, and innovation.

	Existing	Design	Construction	New Building
Carbon sprint	●	●	●	
Retrofit analysis	●			
Energy modeling services	●	●	●	●
Cost benefit analysis	●	●	●	●
Incentive analysis	●	●	●	●
Design services	●			●

In most cases, constructing new buildings generates more carbon emissions than repurposing existing buildings. This is primarily due to the lower embodied carbon existing assets ‘bring with them’.

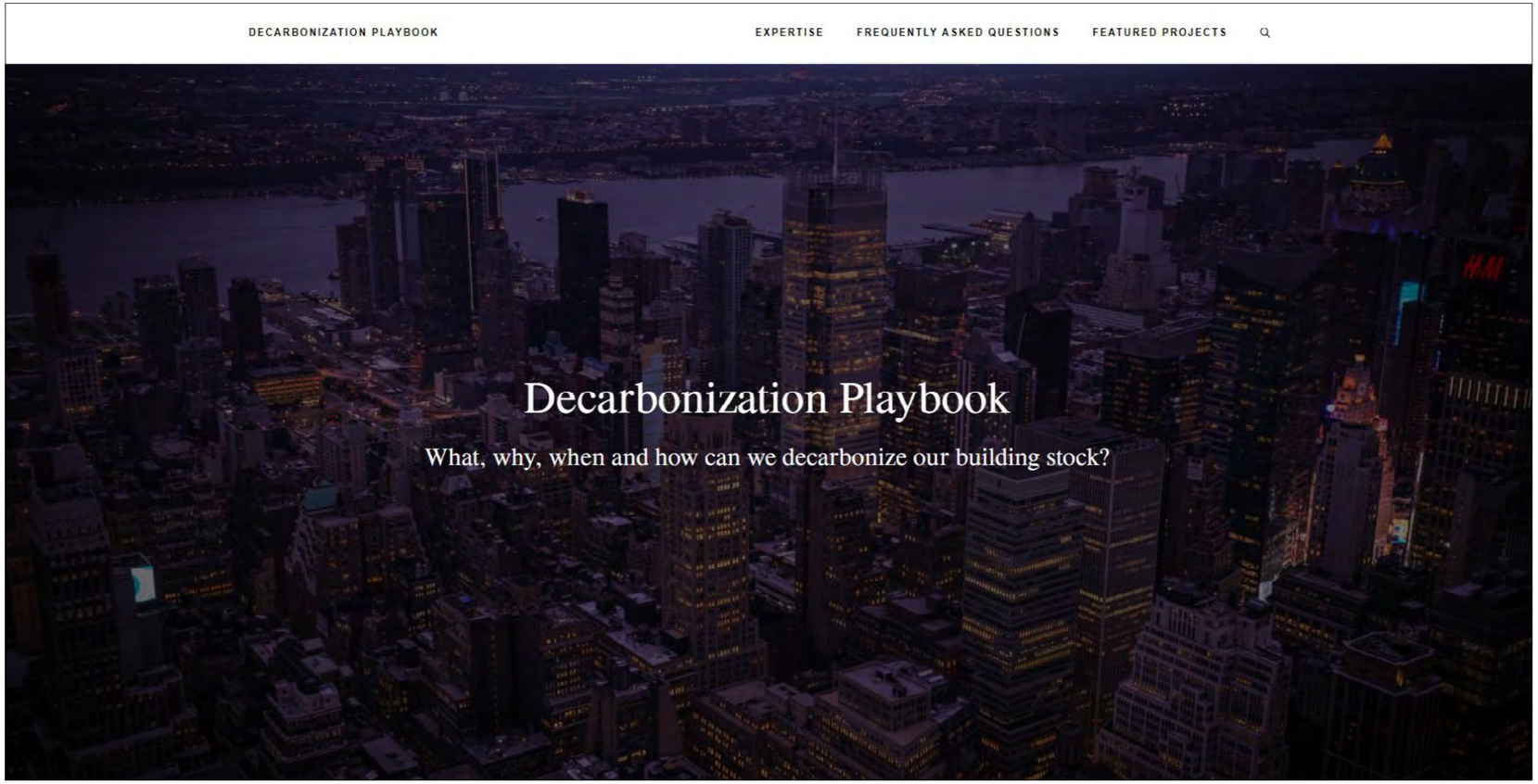
Low carbon solutions

Decarbonization Playbook

Arup has developed a playbook of solutions to help clients identify tangible solutions that suit their situations.

Carbon Sprint

For rapid insights into your unique circumstances, Arup offers a 3-day review to create a tailored low-carbon future roadmap for clients.



Acoustics/AV/Venue Planning

Arup's acoustic consulting practice began in 1967 when we worked with composer Benjamin Britten to transform an abandoned malt house into the world-class Snape Maltings concert hall.

Since then, Arup has provided acoustical, audiovisual (AV) and venue consulting on a broad range of existing building types globally. We can help repurpose existing assets by:

- Surveying and benchmarking existing assets to understand as-built noise and vibration conditions
- Reviewing and drafting lease language to help new functions comply with noise and vibration obligations
- Helping asset owners define targets and meet standards for sound and vibration for new functions
- Supporting entitlements to rezone for entertainment or alternate use
- Simulating the sound environment of new functions in the Arup SoundLab
- Planning the user experience to help define how new tenants will use the existing asset
- Designing acoustical interventions, AV equipment and theatrical systems that respect and enhance the architecture's historic character

©Floto+Warner/OTTO

©Floto+Warner/OTTO

National Sawdust: Arup helped transform a former sawdust factory in Brooklyn into an intimate music venue with adjustable acoustics, staging, and seating to support a versatile range of classical, jazz, modern, and contemporary music performances.

©Jeremy Young

Snape Maltings

©Andre Constantini

In the Arup SoundLab, we can listen to the acoustics of an existing asset and compare design options for reshaping the sound environment to better accommodate new functions.

Acoustics/AV/Venue Planning

By surveying noise and vibration conditions at an existing site, we can develop mitigation solutions for new high- performance functions, expanding the range of possible building uses. This could include repurposing a commercial space into a vibration-sensitive lab, for instance.

National Basketball Players' Association: Arup developed vibration mitigation solutions to enable basketball courts to be constructed in between commercial office floors in a midtown skyscraper in New York.

New Lab: Arup advised on retrofitting a cavernous former shipbuilding factory into a more intimate, acoustically comfortable coworking space and event center.

Circadian Lighting

The wellness benefits of circadian lighting are scientifically documented and earned a Nobel Prize in 2017. Arup has collaborated with researchers and practitioners to develop a definition and strategy for applying circadian lighting science in the built environment and is well poised to help clients enhance the health benefits of their built assets.

In touch with natural light

A circadian lighting strategy is one where lighting design supports the human diurnal need for illumination and darkness cycles in tune with their circadian system. This strategy should include both natural and artificial lighting and should take into account the changes in color spectrum, intensity and directionality over the course of a day. A circadian lighting strategy is not just a lighting product list to specify.

Design for daylight

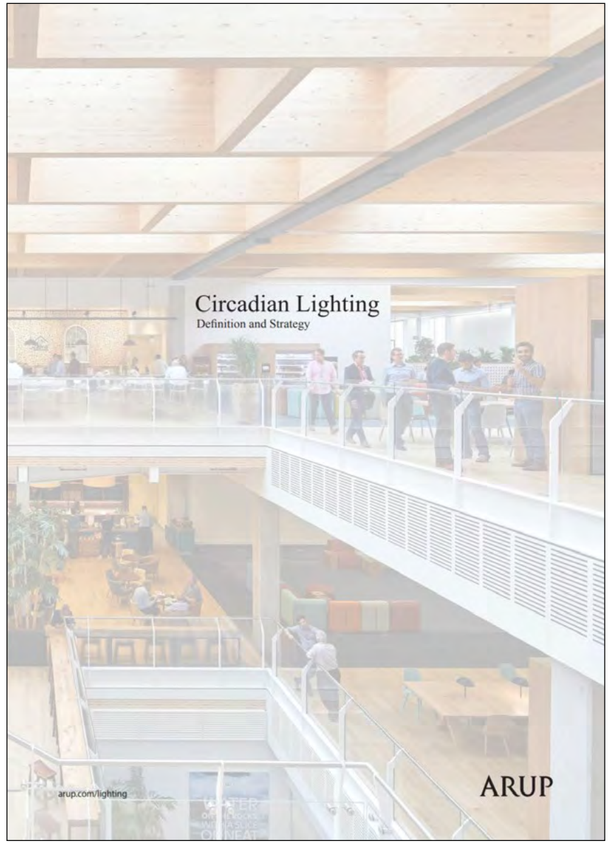
- Sequential spatial experience
- Access to sunlight
- Flexible shading

Supplement with electrical light

- Spatial distribution/contrast and visual experience
- Variation
- Activity based

Control

- Daylight responsive
- Personal control
- User interaction



Please click this link to download a copy of our brochure—Circadian Lighting, Definition and Strategy.

Glare and Visual Comfort

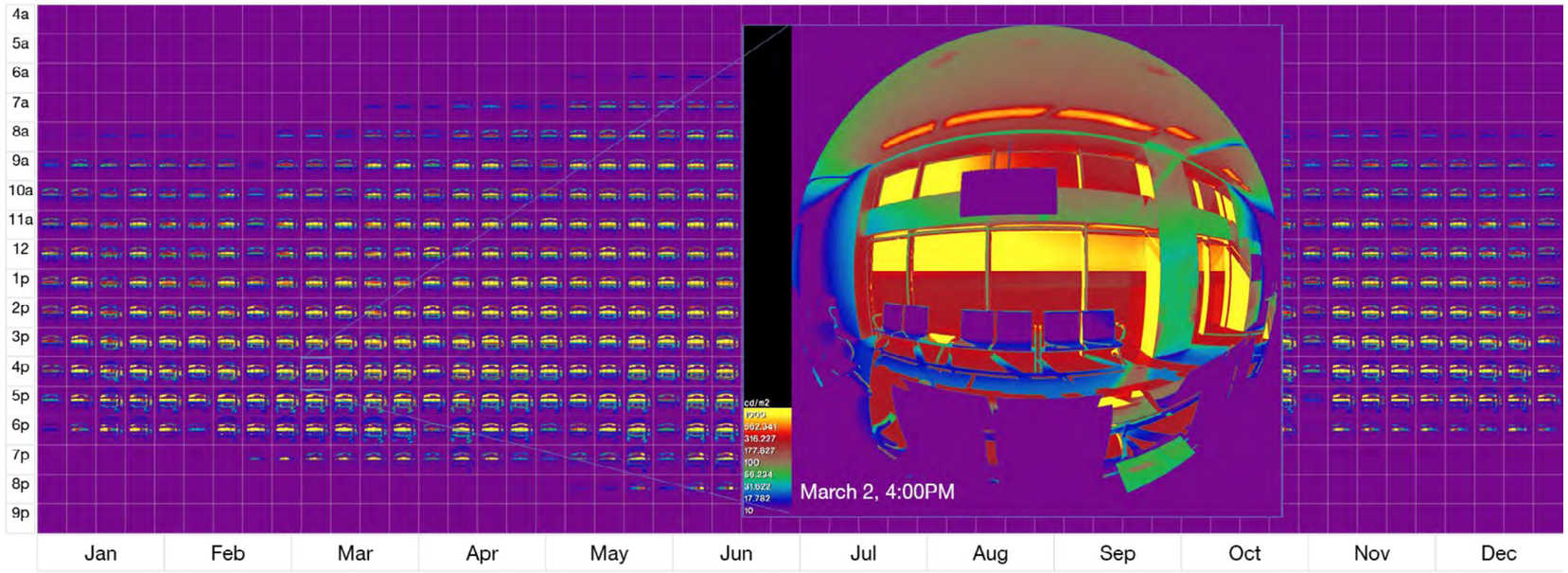
Visual comfort

Existing buildings can present visual comfort and acuity challenges. Unique opportunities for glare mitigation and increased occupant comfort arise when modifying existing fenestrations.

A successful interior daylighting scheme is marked by the level of comfort experienced by building occupants. Excessive and ineffectively controlled daylight can lead to discomfort and/or disability glare, thereby lowering occupant satisfaction and posing increased safety hazards. Achieving high levels of visual comfort for occupants requires a deep understanding of the local climate, solar geometry, architectural massing and human perception.

First principles to glare analytics

Arup’s daylighting approach is grounded in first principles perspective to ensure that a project's spatial needs are met. The most appropriate light planning, glare analysis methodology is then utilized to address the specific needs of the project. Arup uses a variety of technologies, including high-end visualization techniques, to communicate visual comfort performance to clients in a precise and meaningful manner.



Framework for Historic / Heritage Lighting

Our storied experience in the historic/heritage lighting realm has led Arup to develop a lighting strategy that can be tailored to each historic/heritage project.

Survey

Benchmark the existing lighting scene to quantify visual characteristics, such as shade, brightness, and contrast. Determine the key viewpoints, approaches, and journeys to the building or space.

Research

Research the site history to form the basis of the lighting strategy and luminaire treatment, including any requirements for replica luminaires. Establish a timeline of events and modifications to the project, including architectural intentions, social opinion, local and national events, luminaire modifications, and light source developments.

Classification

Designate a classification to each of the existing luminaires for early validation that aligns with the project-specific Heritage Management Plan1. Define the principles of the lighting treatment for each luminaire classification.

Luminaire restoration

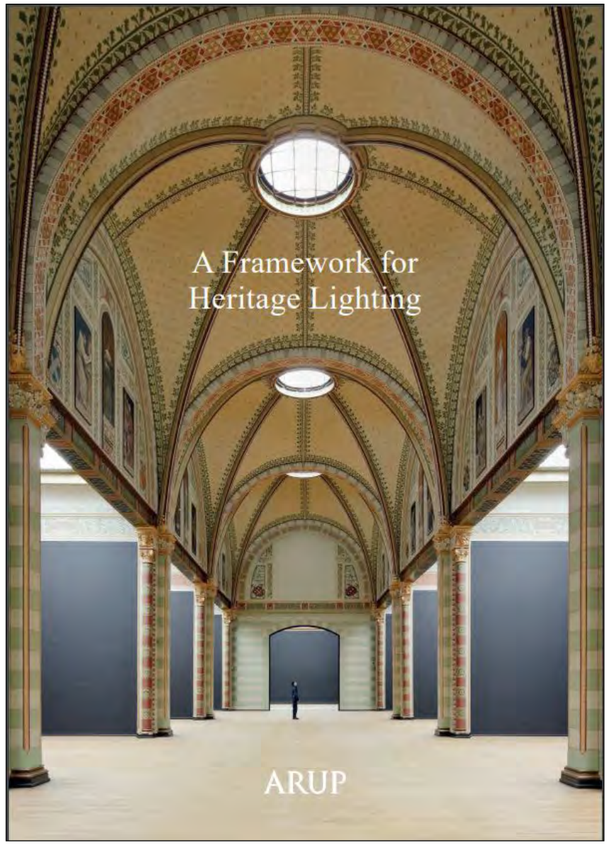
If no luminaires are classified as ‘heritage,’ move to Step Five. Create a lighting specification for each luminaire that connects to findings in Step Two. Remove a sample of luminaires for closer inspection to determine their construction, condition, and materiality and confirm their age.

Technical

Determine the most suitable light source and qualities for each space by analyzing survey results in Step One and completing mock-ups as needed. Consider appropriate use of lighting technology, energy use, and sustainability. If suitable, incorporate other services within the restored or replica luminaires, such as location-based services, WiFi, and CCTV equipment.

Lighting strategy

Balance the lighting strategy between the conservation requirements and the modern lighting design guidance requirements. Specify a lighting strategy for each type of space in accordance with the conservation principles of the project.



Please click this link to download a copy of our brochure—
A Framework for Heritage Lighting.

Framework for Historic / Heritage Lighting

Driven by a keen desire to understand the unique cultural context within which we are designing, Arup's lighting designers create thoughtful, sustainable, and award-winning concepts with light.

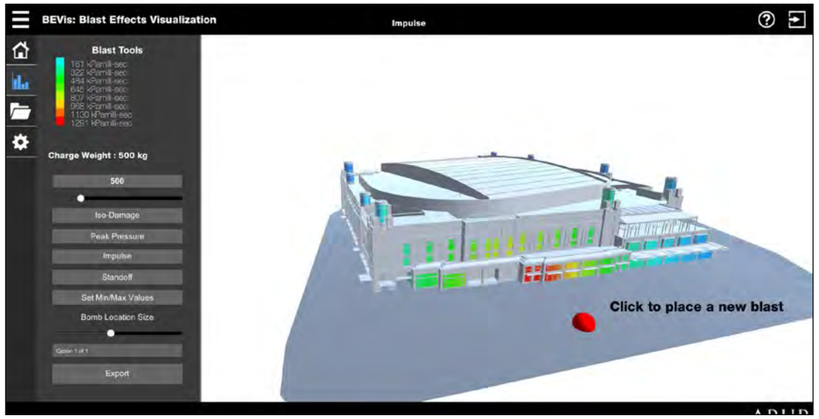
From sensitive historic interventions to engagement with the public via interactive lighting experiences, we combine creativity with technical expertise to propose empathetic solutions that enhance and preserve historic authenticity.

Lighting services include:

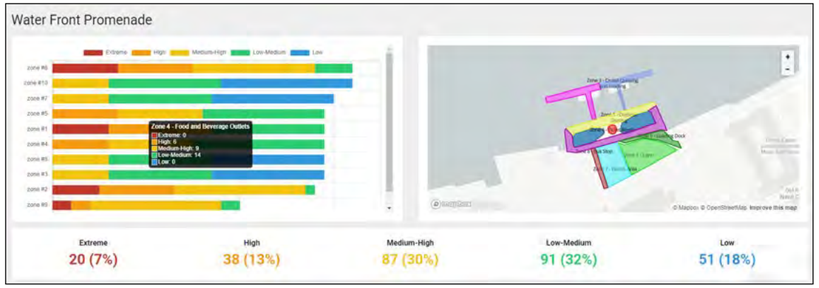
- Feasibility studies
- Historic / Heritage luminaire specification
- Retrofit digital / technical solutions
- Facade lighting
- Content design
- Planning advice
- Master planning
- Daylight analysis
- Environmental impact assessment
- Replica luminaire design
- Bespoke luminaire design
- App development
- External lighting

Security

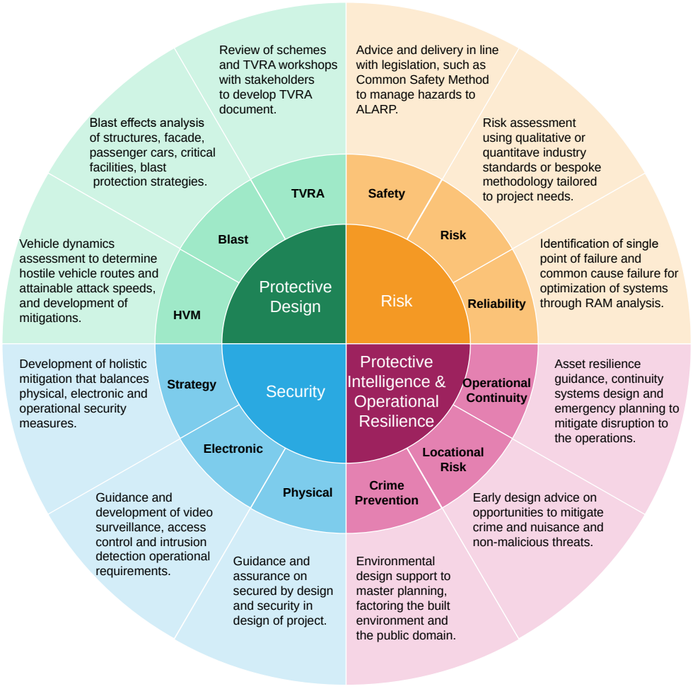
Leveraging the experience we've garnered working on a broad range of security projects worldwide, Arup's industry-leading security consultancy helps clients develop solutions to more effectively manage and mitigate risks related to operations, personnel, and property assets of all kinds.



Arup's Blast Effects Visualization (BEVis) software provides decisionmakers with an interactive experience to understand the blast performance of a building's glazed elements and explore risk mitigation options.



Lyra is a digital dashboard designed to enable owners to understand the risk levels of different zones or asset groupings across a site or portfolio of properties.



Key drivers to retrofit

Safety

- Fire & code
- Increased occupancy
- Rehabilitation of degrading fabric
- Security
- Façade

Resilience

- Seismic upgrades
- Flood protection
- Wind
- Wildfires
- Climate change

Wellbeing

- Well
- Fitwel
- COVID-19
- Air quality
- Accessibility to all

Viability

- Portfolio energy assessments
- Smart buildings
- Understanding and managing risk
- Reducing maintenance costs

Value

- Refurbishments
- Renewal
- Façade improvements and building re-clads
- Flexible spaces

Sustainability

- Low and zero carbon solutions
- Benchmarking
- Code-driven upgrades
- Sustainability certifications

Change of use

- Adaptive reuse of existing systems
- Flexible solutions
- Fire & code analyses for change in occupancy

Tenant led improvements

- Lighting, AV & IT
- Stair connectors
- Floor loading upgrades
- Vibrations
- Retaining key staff

ARUP

Case studies

Key drivers: ● Safety ♦ Resilience + Wellbeing ■ Viability × Value ○ Sustainability ⬟ Change of use ▶ Tenant led improvements

■ × ○ ⬟	100 Van Ness ↗
● × ○	1271 Avenue of the Americas ↗
+ × ○ ⬟	1633 Broadway Residential Conversion ↗
× ○	80 M Street ↗
● + ■ × ○ ⬟	Accident Fund National HQ ↗
▶	Americas region office signage and wayfinding guidelines ↗
● ♦ ■ × ○	Amon Carter Museum ↗
♦ ⬟ ▶	Boston Architectural College, 951 Boylston Street ↗
+ ♦ ○ ⬟ ▶	Bruce C. Bolling Municipal Center ↗
+ ■ ○ ⬟	California State University John Spoor Broome Library ↗
● ♦ × ▶	Campus-Integrated BMS ↗
● + ■ × ○ ⬟	Corbin Building ↗
♦	COVID-19 return to workplace ↗
♦ ■	COVID-19 return to workplace, lobby plans ↗
■ ○	Designing for compliance with Washington, D.C. District building energy performance standards ↗
● ■	Digital Masterplan ↗
● ♦ ■ ○	Guy’s Hospital Tower Wing ↗
+ ⬟ ▶	Harvard University Smith Campus Center ↗
● + ♦ ■ ○	John Ferraro Building Sustainable Modernization Assessment ↗
● + ■ ×	Judicial Council of California Seismic Renovation Study ↗
● + ■ × ○	Kimbell Art Museum ↗
● + × ○	King Street Station Restoration ↗
+ × ○ ⬟ ▶	King’s Cross Central Development Coal Drops Yard ↗
● + ■ × ○	LAX RS-X Receiving Station signage ↗
⬟	Long Island Railroad offices ↗
● + × ▶	Los Angeles Memorial Coliseum ↗
● × ⬟	MASS MoCA Building 6 ↗
♦ ×	MTA Enhanced Stations Initiative ↗
× ⬟ ▶	New Scotland Yard ↗
■ × ○	Portfolio assessment ↗

ARUP

Case studies

Key drivers: ● Safety ♦ Resilience + Wellbeing ■ Viability × Value ○ Sustainability ⬟ Change of use ▶ Tenant led improvements

● ■ ⬟ ▶	Print Building ↗
♦ ■	Roy and Edna Disney California Arts Theater (REDCAT) ↗
+ ■ × ○	San Antonio Museum of Art ↗
● ♦ ■ ×	Seismic Risk Assessment ↗
● ♦ ○ ▶	Smith College Cutter and Ziskind Dormitory ↗
● ♦	St Paul’s Chapel ↗

● ♦ ○ ⬟	Television Centre ↗
● + ■ × ○ ⬟	TWA Flight Center Hotel, JFK Airport ↗
● + ■ ×	University of British Columbia Seismic and Resilience Study ↗
● ♦ ○ ⬟	University of Massachusetts ↗
● + × ▶	USC Stevens Hall Raulston Memorial Research Building ↗
■	Wayfinding for South Street Seaport ↗

100 Van Ness
San Francisco, CA

How do you reclad an existing 400ft precast office tower that has been repurposed as luxury apartments?

At a glance

Arup provided façade consulting services for the reclad of this 1960's California State Automobile Association building located in downtown San Francisco's Civic Center neighborhood. The building was being converted to luxury apartments, significantly increasing its property value. Arup was instrumental in designing the curtain wall systems and the lobby glazing structural movement support strategy, ensuring proper interfacing between the curtain wall / lobby façade systems and the existing primary structure.

Solar studies were also carried out to ensure that the all-glass building would not compromise the overall energy performance targets and mechanical system design.

Safety
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Tenant led improvements

1271 Avenue of the Americas
New York, NY

How do you make a building constructed in 1959 energy efficient?

At a glance

This 2,000,000ft² commercial office building stands as a mid-century icon. When the building's core tenant announced it was downsizing and moving to a new location, the building owner took the rare opportunity to upgrade the building's aesthetics and energy efficiency, while still maintaining its iconic historic fabric. To succeed, we had to understand the building's existing conditions, get to the bottom of shifting code requirements, and produce a high-quality set of contract documents.

Drivers

The new design includes a complete replacement of the curtainwall façade, replacement of the associated perimeter mechanical systems, restoration of the historic landmarked lobby, upgrade of the pedestrian plaza, and a new 2,200ft² canopy at the entrance. The new curtainwall will use high-performance double-glazed windows and eliminate the uninsulated ductwork, drastically improving the thermal performance of the façade.

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1633 Broadway Residential Conversion
New York, NY

How do you transform an office building into residential apartments?

At a glance

Office space in our urban centers is currently underutilized as people choose to continue to work from home long after the risks from the COVID pandemic have subsided. Meanwhile, the affordable housing crisis continues in urban areas across the country. The long boom in commercial real estate has culminated with significant new premier office properties coming to market just as the demand for overall office space is being questioned. This combination of shrunken office demand, aging building stock, climate change, lack of affordable housing, and desirability of balanced mixed use neighborhoods presents an opportunity for reinvention of our business districts. Conversion of underutilized and out-of-date office properties to residential can create vibrant 24-hour, 7-day neighborhoods and improve building energy performance resulting in increased asset value over the long term.

Initiatives

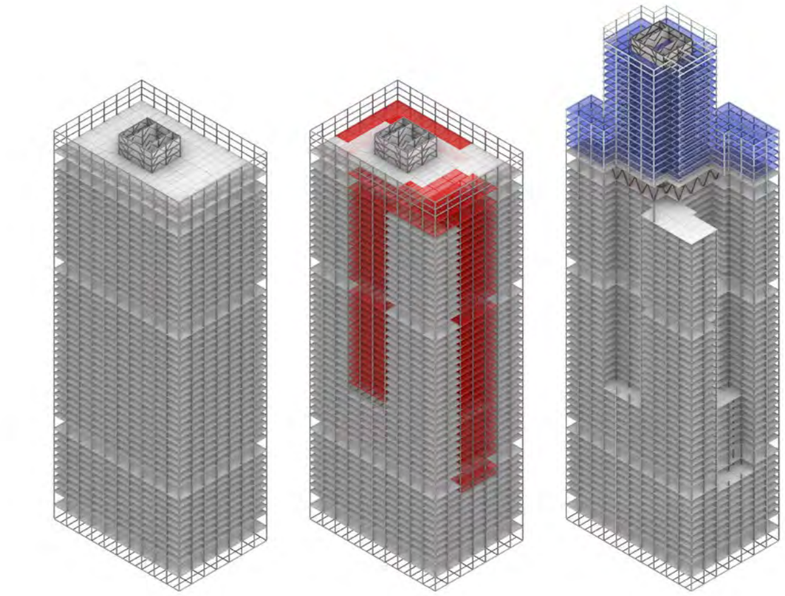
Converting extra deep Midtown office floor plates of the 1960's to one which meets the legally required access to air and light for residential units is a geometric challenge. Many conversions have been done with Financial District office buildings but they tend to have their cores on the side and shallower floor plates than the monoliths of Midtown. Our approach is to carve in from the outside and use the relieved structural capacity to build above. This load re-distribution approach facilitates unit layouts on the 25ft structural grid with generous yet not wasteful square footages as is found in Soho loft conversions. The apartment layouts take the NYC Deptartment of Housing Preservation & Development design guidelines as the starting point and take advantage of the existing floor area to add comfortable work/study spaces.

Structural engineering

The existing structure for 1633 Broadway consists of concrete slab on metal deck supported by steel beams spanning to steel columns which are founded on bedrock. A steel braced frame system surrounding the central elevator cores provides lateral stability for the tower and resistance against wind and seismic loads. Columns are spaced around the perimeter of the building on a 25ft column grid and the lease span between the core and façade has an intermediate line of internal columns which limits beam spans to roughly 25ft.

Sustainability

Sustainability is fundamentally embedded in the project, from the reuse of most of the existing building to upgrading and electrifying outdated operational and systems. This proposal goes farther by integrating holistic sustainability strategies into the design. Sustainability here consists of five categories: Energy and Emissions, Embodied Carbon, Water, Indoor Environmental Quality, and Site and Landscape.



Current building | **Proposed demolition** | **Proposed construction**

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80 M Street
Washington, DC

How do you maximize the allowable height of an existing office building?

At a glance

80 M Street is an existing commercial office building in the Navy Yard neighborhood of Washington, DC. Originally constructed in 2000, the building had unused allowable building height that the owner sought to maximize while keeping the existing building fully operational for tenants during construction. A vertical addition utilizing mass timber was schemed with Hickok Cole Architects to reduce the weight on the existing structure while creating a distinctive product in a densely developed commercial office neighborhood.

Mass timber

Mass timber was chosen for the vertical expansion to minimize the weight and impacts to the existing building below, eliminating the need to reinforce existing structure within tenant spaces. Arup's expertise in mass timber design was demonstrated in the full-service offering provided for the project, including structural, mechanical, electrical, and plumbing engineering and code and acoustics consulting. Arup's code consultants worked closely with the local building authority, architect, and owner to develop a code approach that allowed for a 2-hour rated exposed timber structure. An integrated design between fire and structure achieved the fire rating for the exposed structural elements and their connections.

New mechanical system

The new three-story addition features tenant floors with large floor-to-floor heights and a tenant amenity space on the penthouse level with accessible terrace. To minimize the loss of square footage to mechanical space on these desirable floors, Arup developed a new, separate mechanical design for the addition. Using a Variable Refrigerant Flow (VRF) system with a Dedicated Outside Air System (DOAS), valuable tenant space was maximized on the new floors. Larger equipment and pumps were relocated to the 7th floor of the existing building to further minimize impacts. Existing base building mechanical equipment was relocated to a new mechanical yard on the penthouse roof. The DOAS system is equipped with MERV-13 filter which will help to improve indoor air quality and has been proven to be effective on capturing COVID-19 aerosol.

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Accident Fund National HQ
Lansing, MI

Structural challenges

The original power station was a masonry-clad, early steel-framed structure. There were few floor plates, simply gantries, and catwalks spanning between equipment supports designed to carry heavy loads. Building a modern office facility within the existing shell therefore required a creative structural design.

Arup devised a ship-in-a-bottle-inspired solution to facilitate the removal and replacement of the existing steel structure while leaving the masonry walls intact. The team lifted over 1,000 tons of existing steel framing through two temporary 14x40 ft roof hatches at the top of the nine-story tower, and then lowered in almost 2,000tons of new steel. The new structure was subsequently erected using a detailed plan developed in BIM.

Client's aspirations

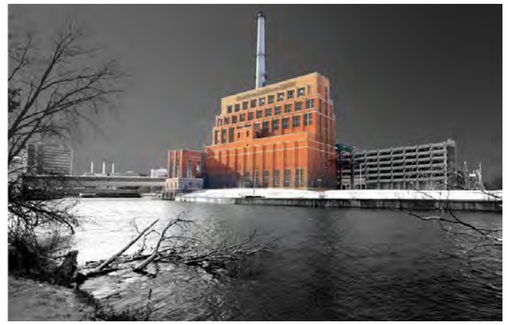
Transforming a disused power plant into Class A office space while retaining the building's distinctive character.

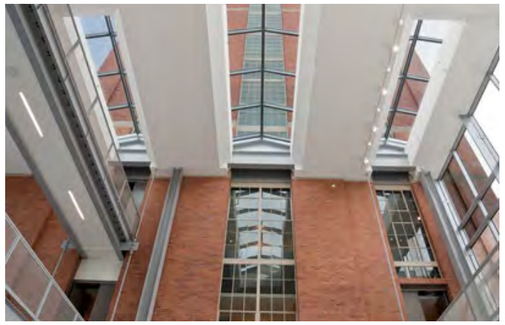
Sustainable design

The final design incorporates cost-effective and flexible underfloor air supply systems. Targeted improvements to the building envelope reduced operational expenses. For instance, we substituted hi-tech glass for more traditional historic glass throughout the building to curb solar gain, thereby reducing the size of the building's HVAC systems and freeing up floor space. In addition, Arup's MEP engineers used energy modeling to help the client maximize their capital investment and create a more sustainable headquarters.

Façades

Arup façade engineers worked closely with the architect and Arup structural engineers to retain the existing glazing system and avoid removing delicate time finishes throughout the interior of the turbine hall.





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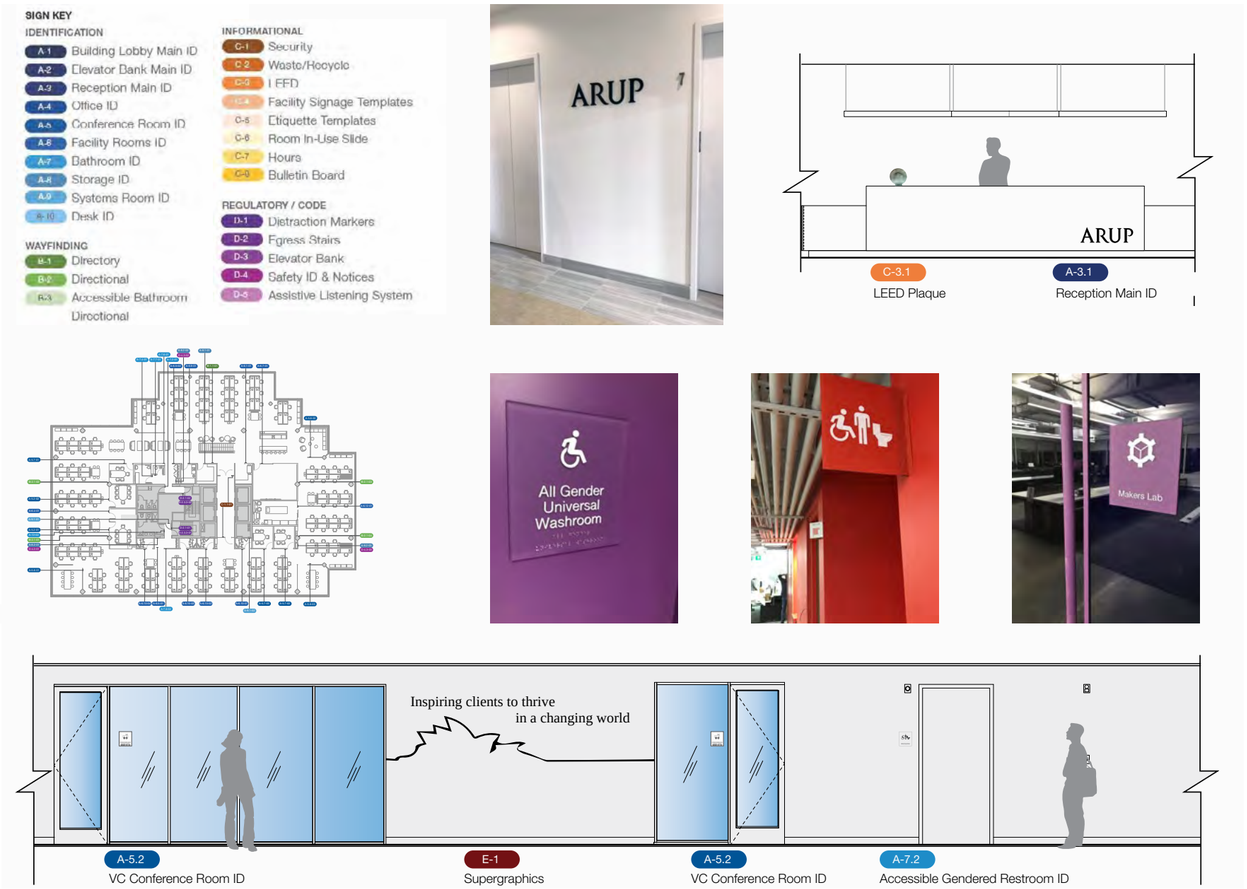
Americas region office signage and wayfinding guidelines

At a glance

Arup developed in-house signage and wayfinding guidelines for use in Arup offices across the Americas region. The guideline helps promote consistency and familiarity across the region for employees and visitors to the Arup offices, while streamlining design and implementation to increase efficiency in office signage and wayfinding projects.

The signage system adheres to the existing Arup brand standards, is ADA compliant, and developed for a variety of users with different abilities. It comes with associated template files for operational needs to be maintained and updated by each office's facilities staff.

The system is flexible enough to adapt easily to a variety of office needs and architecture, code, and geographic differences, and allows enough variation to reflect "local flavor."



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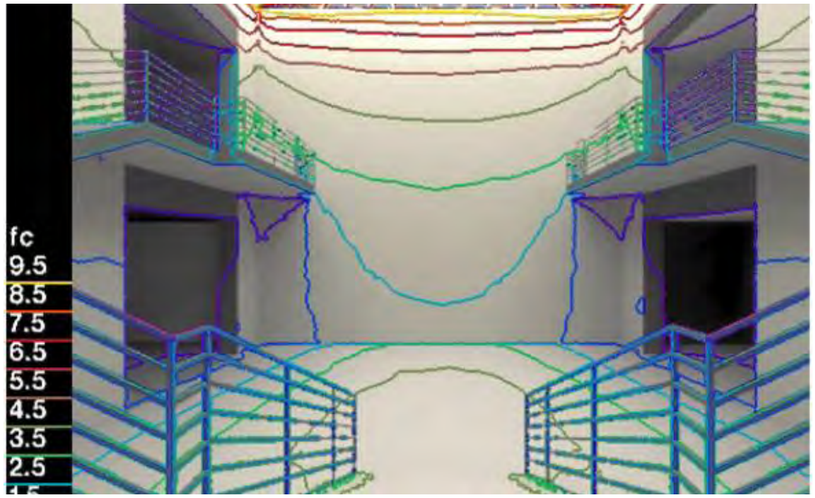
Amon Carter Museum
Fort Worth, TX

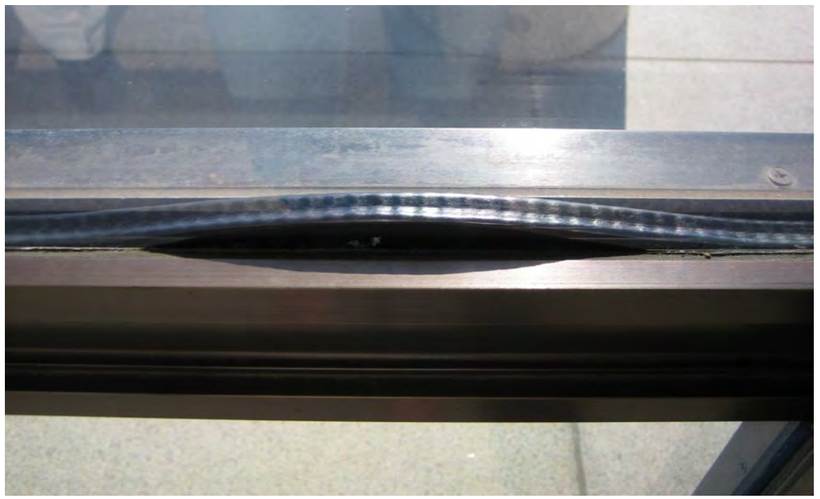
How do you renovate an architecturally iconic museum from 1961 to address art preservation and infrastructure upgrades?

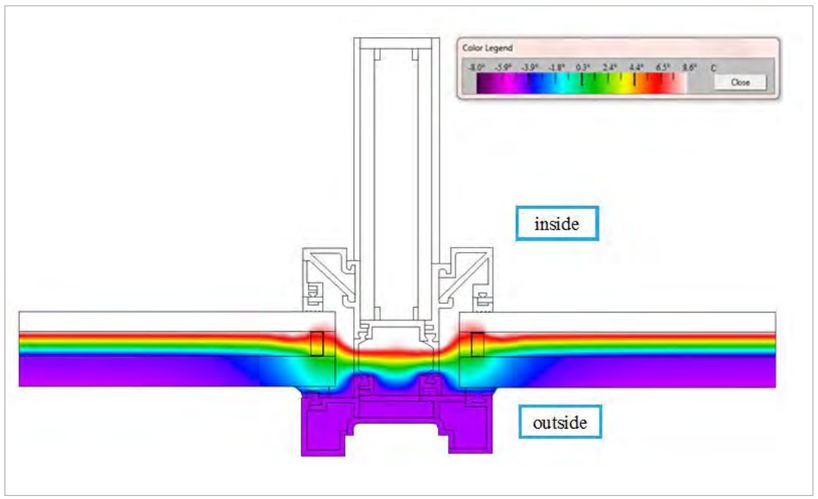
At a glance

Renovation and infrastructure upgrades of the iconic 70,000ft^2 Amon Carter Museum, originally designed by Pritzker Prize winner, Philip Johnson “preserved and enhanced” Johnson’s original architectural vision. The fully-glazed East Façade leading to the Sculpture Gallery was redesigned with larger façade panels, which was Johnson’s original design intent. This façade was improved to include thermally-broken mullions and new solar-control glazing to mitigate condensation risk and to help protect photo-sensitive artwork further into the museum space. A thicker overall glass build-up on the new façade helped address the glass pillowing, that was occurring on the old façade. Arup also took an integrated design approach to ensure the façade design options were fully coordinated with and complementary to the mechanical system upgrades.

Additionally, Arup provided façade options to address a water ingress issue at the South Entrance and to make this entrance ADA compliant.







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Boston Architectural College, 951 Boylston Street
Boston, MA

How do you transform a historic police station and art institute into a fully accessible architectural college?

At a glance

The renovation of 951 Boylston Street was part of a multiphase project to restore the building's exterior to its original state while adapting the interior to a modern teaching, exhibition, and gathering space for Boston Architectural College (BAC) students, faculty, and the public.

Open to all

Arup provided a survey of the existing systems for the building, which originally served as the Back Bay Police Station and then as home to Boston's Institute of Contemporary Art. 951 Boylston Street is the first new campus building opened by BAC in nearly 50 years and includes student meeting spaces, academic studios, a lecture hall, and a gallery for the BAC.


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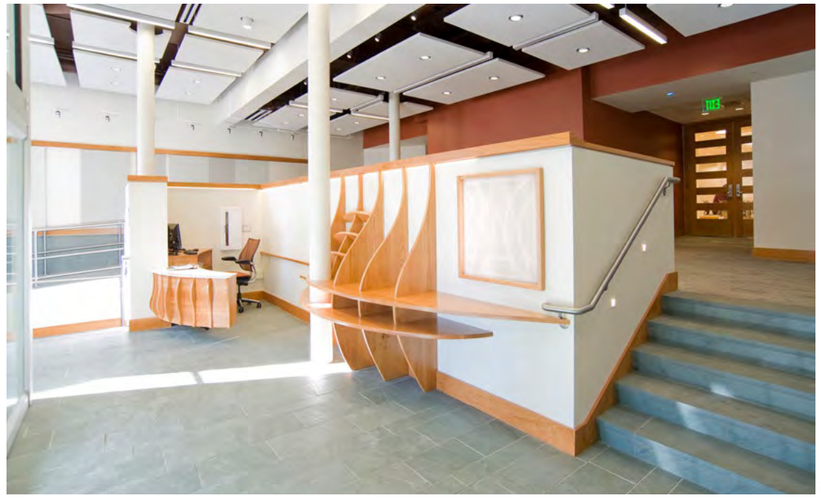
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Bruce C. Bolling Municipal Center
Roxbury, MA

How do you transform a scattered public education administration into revitalized community anchor?

At a glance

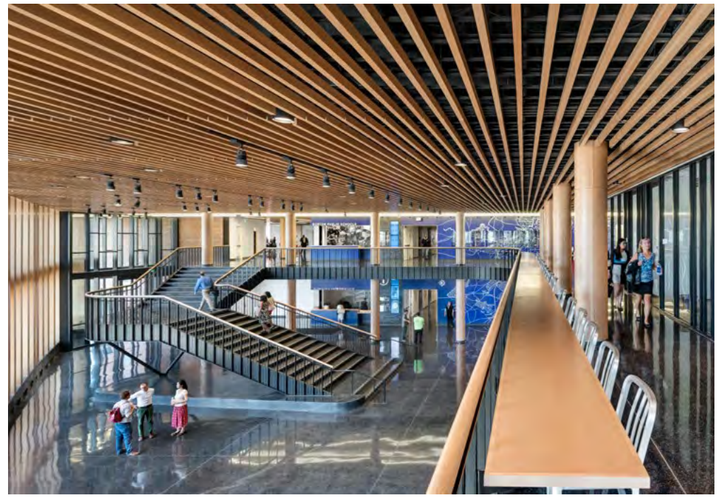
Parents or guardians seeking services for their children from the Boston School Administration would often have to navigate between disparate offices scattered throughout Boston's Back Bay neighborhood. Mayor Thomas Menino supported a vision to reinvigorate a Roxbury neighborhood with a bold new centralized administration high-rise above a re-engaging mixture of commercial services at ground level, all housed within a modern infill between historic building facades.

Efficiency within

To improve overall performance, Arup adopted a "whole building energy approach," using a range of solutions, including energy-efficient lighting, an active chilled beam system, and energy recovery air handling units. Arup's mechanical and structural engineers also worked together to find the best approach to weaving together the center's old and new walls.

Community impact

Since its opening in 2015, the Bolling Municipal Center has been widely noted for its sensitive design, which brings the aesthetics and energy performance of Dudley Square into the 21st century while honoring its origins.



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California State University John Spoor Broome Library
Camarillo, CA

How do you transform a hospital into a library?

At a glance

This 137,000ft² library consists of a 66,000ft² renovation and seismic upgrade to existing historic Mission-style buildings that were originally used as part of the California State Mental Hospital. The renovated space now serves as reading rooms and classrooms, while a 71,000ft² contemporary addition houses the heavier loads of the book collection.

The library's central reading room features a translucent glass ceiling that transmits indirect sunlight to reveal the library stacks and the exterior wall of the original 1930s construction. Structural elements are exposed, and mechanical systems were coordinated with the bookstacks to achieve an integrated design and aesthetic.

Seismic strategy

The seismic retrofit strategy of the existing concrete included the introduction of seismic separation joints to reduce the aspect ratio of floor plates. The preceding strategy facilitated significant reduction in concrete shear walls by minimizing the torsional/rotational dynamic response in earthquakes.

Sustainable development

Adaptive reuse of existing structures meant that fewer new materials were needed and less solid waste was sent to landfill during construction. The use of recycled content concrete and a low-energy mechanical and electrical system adds to the university's overall commitment to developing and maintaining a sustainable campus. The design and construction process for this project lasted more than nine years.

Energy efficient

The use of different roof cladding systems protects the new reading room from direct sunlight, while still allowing natural daylight into the spaces. The building envelope is highly energy efficient with both the new and existing building fabric thermally upgraded to exceed current Title 24 Energy standards yet maintain the historic features of the existing structure. Direct solar gain is minimized in order to reduce energy consumption and minimize ultraviolet light degradation of the book collection. Extensive indirect daylighting means daytime artificial lighting operation is minimized.

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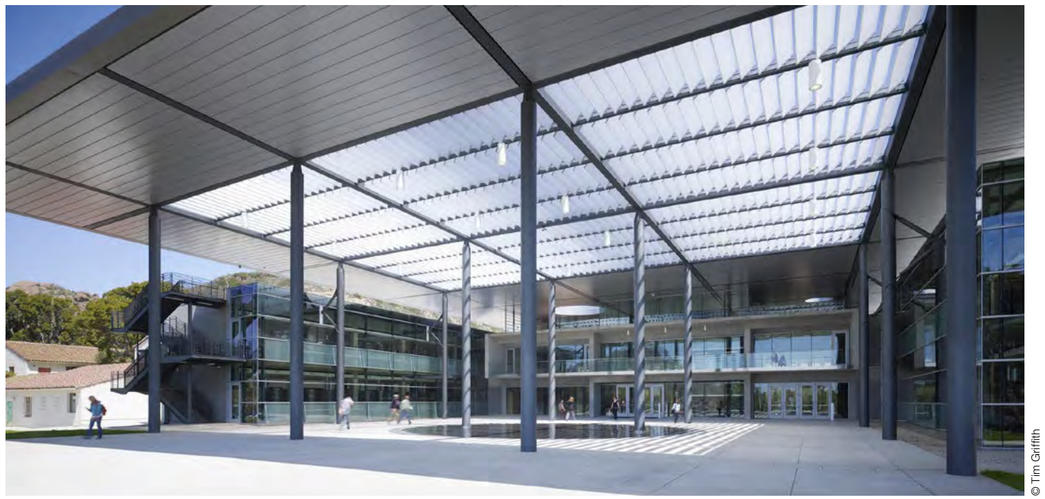

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Campus-Integrated BMS Midwest

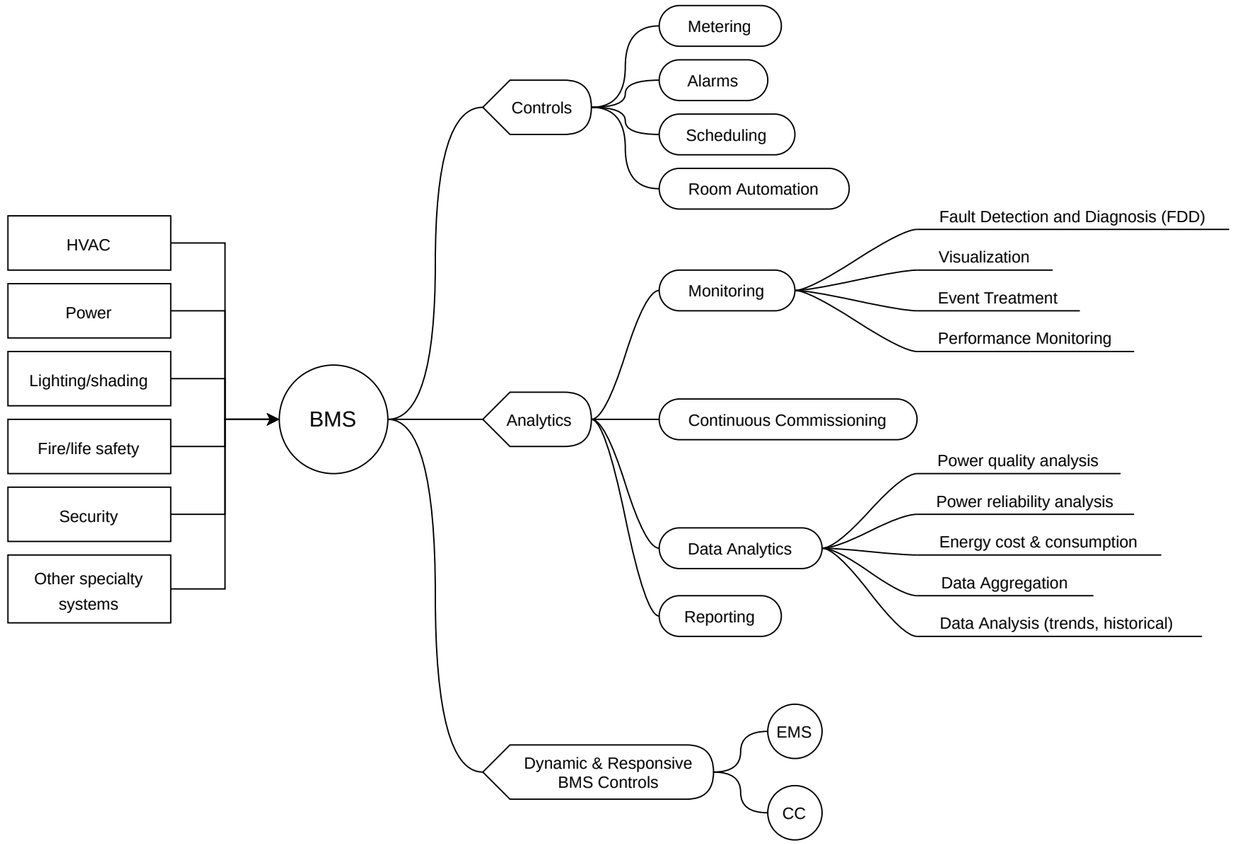
How do you improve the building management system (BMS) across a portfolio?

At a glance

Arup developed BMS and MEP Standards and Guidelines and an associated migration strategy for the campus. These efforts form the baseline of an approach that will be deployed across the owner's nationwide portfolio.

Standardizing systems

Four key buildings were selected in the first phase. The BMSs for these properties have mixed system types, manufacturers, and operational profiles, leading to maintenance, user comfort, and operational efficiency challenges. To help move these facilities to a common BMS and MEP approach, Arup began by defining and documenting the existing conditions via physical surveys on all four buildings to assess the condition of existing HVAC, BMS, and MEP systems and to verify as-built documentation. From this effort, Arup and the client developed an upgrade strategy and schedule. In parallel, the team defined desired outcomes from reference architectures and design team instructions in a Standards and Guidelines document for MEP and BMS to guide future facilities design and construction. Custom strategies for the evolution of existing and outdated systems were also developed and a roadmap created to meet client budget, schedule, and operational needs. Arup is currently working on the next evolution of the Standards and Guidelines to include the client's nationwide portfolio and to further standardize systems architectures into a plug-and-play methodology.



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Corbin Building
New York, NY

At a glance

The Corbin Building is significant for its aesthetic and technological contributions to the history of American architecture.

Building on our heritage

Designed in 1888 by Architect Francis Hatch Kimball for banker and real estate developer Austin Corbin, the nine-story Corbin Building is a proto-skyscraper. Predating the use of pneumatic-driven caisson footings that make the steel-frame construction of true skyscrapers possible, the building's structure is still supported by load-bearing masonry walls. At the time of construction, the Corbin Building was the tallest office building in Manhattan.

Structural modifications

The New York Building Code, as it existed in 1888, contained neither seismic nor wind loading standards. The structure used a mixed frame of cast iron columns, guastavino vaults, and masonry shear walls for support.

While constructing a new deep escalator through the hearth of the building, Arup was also able to locally strengthen the Corbin Building and tie the structure to the new pavilion building located to the north. The result is a unified system of support, and a building that is significantly stronger than before.

Security

Hardening of the historic façade is hidden behind the restored storefronts and masonry cladding to the cast-iron columns, providing a safe environment for retail and transit users. Arup also carried out extensive blast analysis for the new glazed façade, and integrated impact loadings from the new bollards surrounding the site to ensure that standoff distances are maintained and pedestrians are protected.

Fire & code

Fire & code analysis played a major role in the reshaping and preservation of the building. By providing an alternate egress to the north side (created by punching localized penetrations through the masonry wall), we were able to remove the previous fire escape stairs from the historic façade while leaving the lobby's monumental staircase intact.

© Wade Zimmerman

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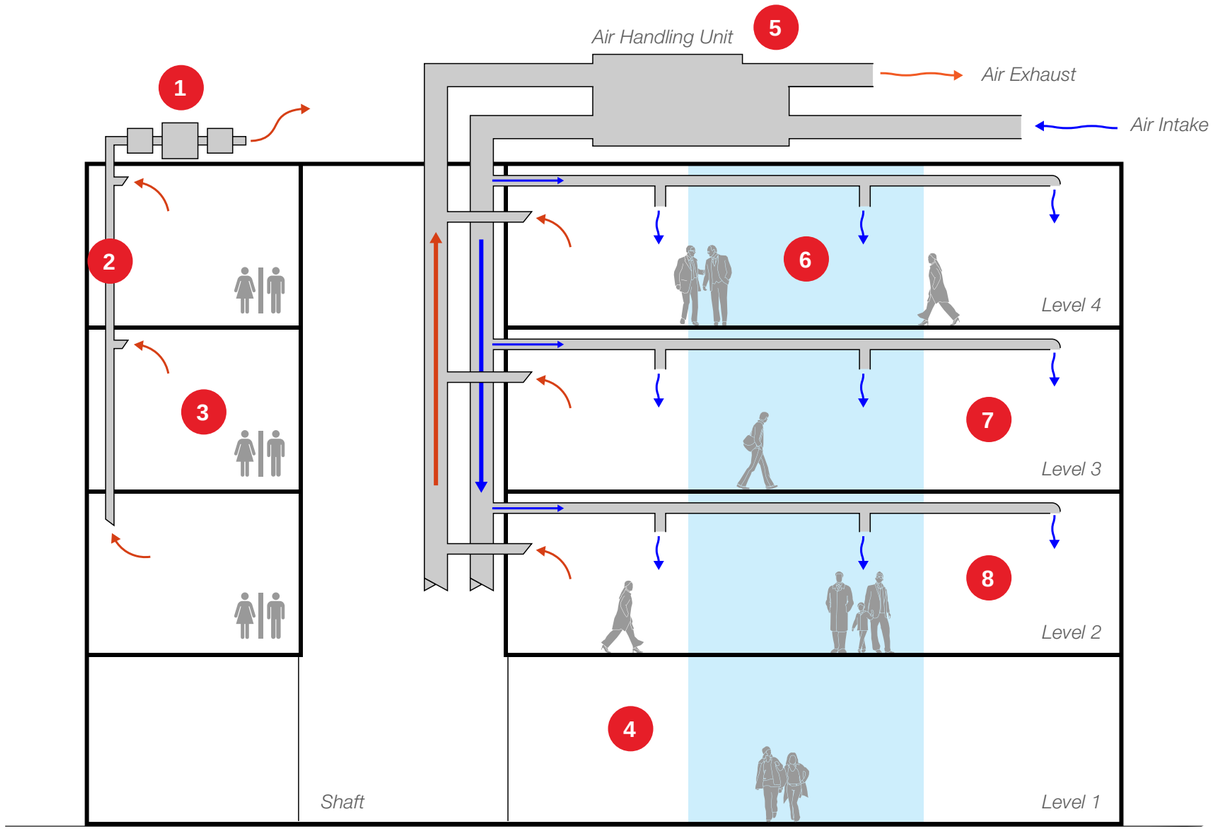
COVID-19 return to workplace
Multiple locations

What are the key characteristics of a COVID-resilient building?

Partnering with Arup's retrofit experts can help building owners determine the best path to reducing the overall risk of transmission and implement appropriate and economical measures that support better health and wellbeing outcomes in the long term.

Arup offers building owners a full suite of pandemic-preparedness services designed to safeguard staff without compromising an organization's larger sustainability and business goals. We have worked with numerous clients to:

- Identify opportunities for increased exhaust and negative pressurization
- Evaluate the impact of COVID best practice measures on electrical infrastructure, and provide recommendations
- Reduce risks from droplets and droplets residue from plumes
- Optimize filtration while supporting environmentally-friendly operation
- Assess economizer operation and increase outside airflow
- Retrofit buildings to include additional outdoor space
- Enhance existing maintenance regimens
- Evaluate indoor environment for room air changes and humidity conditions and align with the latest COVID guidance
- Optimize BMS controls and implement Sequence of Operation for Emergency use scenarios
- Facilitate zonal control / isolation to enhance safety and increase tenant flexibility



1. Identify opportunities for increased exhaust and negative pressurization.
2. Evaluate Electrical Infrastructure impact from COVID best practice measures.
3. Reduce the risk from droplets and droplet residue from plumes in the air.
4. Retail operation impact on central system.
5. Optimize filtration while ensuring an environmentally-friendly operation. Assess Economizer operation for increased Outside Air flow.
6. Retrofit for more outdoor space.
7. Enhance maintenance regime. Evaluate indoor environment for room air changes and humidity conditions against latest COVID guidance.
8. Optimize BMS controls and implement Sequence of Operation for Emergency use scenarios. Facilitate zonal control/isolation to increase tenant flexibility.

COVID-19 return to workplace, lobby plans
Multiple locations

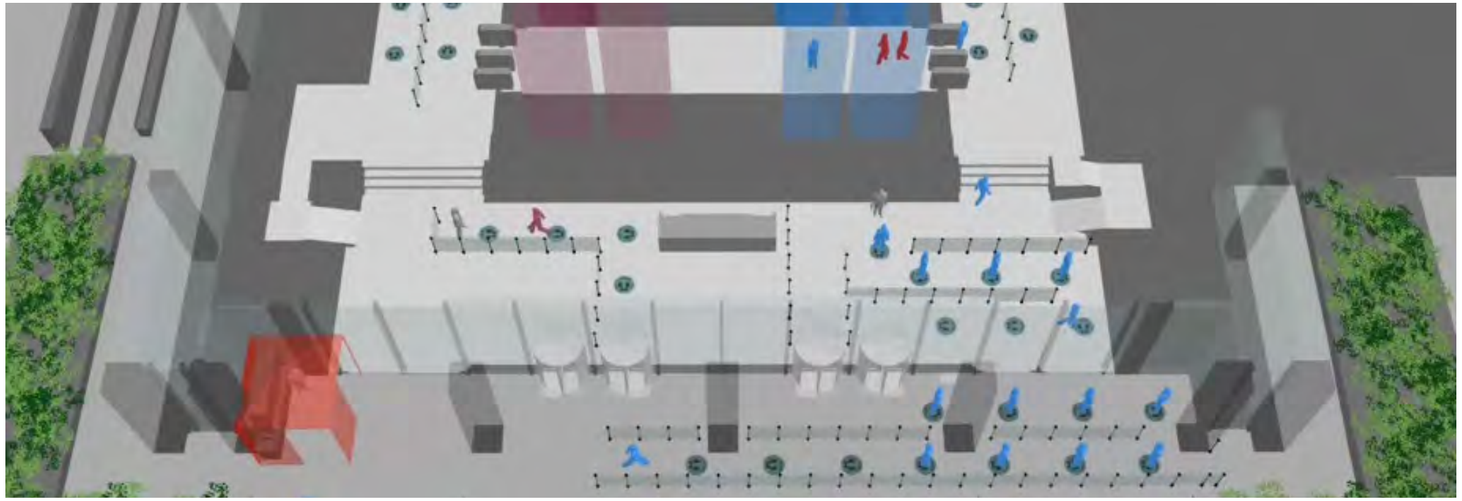
How do we provide employees with a safe and welcoming experience as we return to the workplace?

At a glance

Arup worked with multiple clients to help them safeguard staff and streamline building operations in response to COVID-19. Our wayfinding and user experience team developed new concept layouts and operational plans for dozens of existing buildings. To develop each concept, we considered every step in the arrival and departure sequence and sought to identify all potential limitations created by new social distancing requirements.

Space for social distancing

When tasked with developing pedestrian models of operational changes related to COVID-19 for multiple clients, Arup created MassMotion models to identify appropriate lobby procedures, such as temperature checks and pre-screening, which were used to inform the design and implementation of signage and wayfinding, as well as to determine appropriate capacity for building elevators. We also took advantage of a new feature in MassMotion that was specifically designed to respond to the COVID-19 crisis where the people in the model (“agents”) turn a different color when they come within 6’ of one another. This allowed us to test multiple layouts and operational procedures to understand how they performed in regards to social distancing.



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Designing for compliance with Washington, D.C. District building energy performance standards

At a glance

As part of a team lead by the Institute for Market Transformation, Arup helped to determine the structure of a new D.C. resource center dedicated to helping the building industry prepare for the arrival of D.C.'s heightened energy efficiency standards or buildings.

Our engineers and consultants helped the team identify knowledge gaps, categorize general understanding of upcoming policy mandates; and identify best practices, opportunities, challenges, and timelines for building electrification in the D.C. climate zone. This work has advanced our knowledge and approach to design solutions beyond many of our local competitors.

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Digital Masterplan
Boston, MA

How do you support a development with future-ready planning?

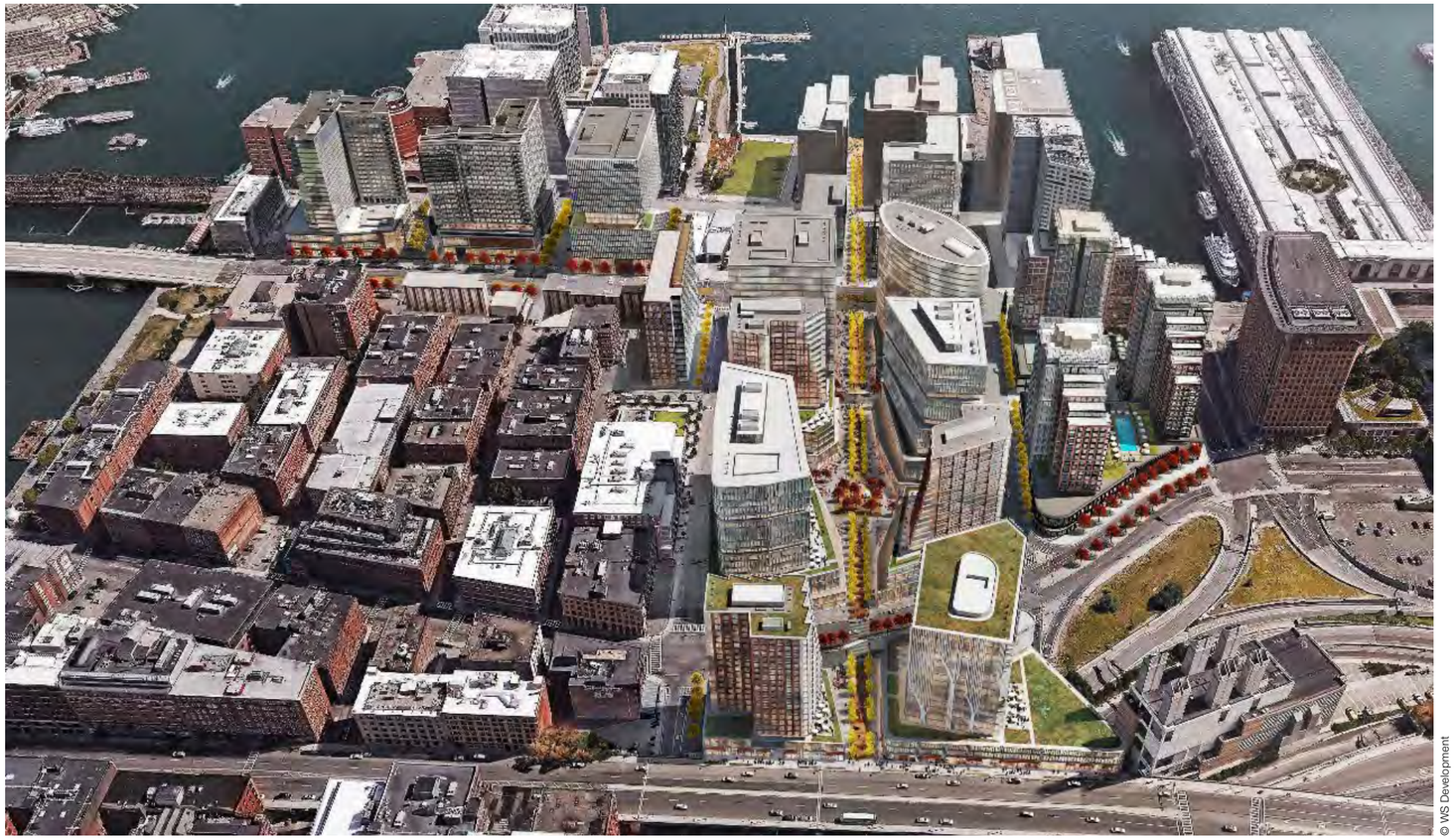
At a glance

Through evaluation and prioritization of current and future desired client outcomes, Arup developed a Digital Masterplan addressing the site's operational and communications systems.

Standardizing systems

Arup collaborated with the developers of this mixed-use site to create a Digital Masterplan. It defines existing and potential future ICT services, networks, and infrastructure to support a full range of digital activities and stakeholder engagement.

The Arup team evaluated the site's physical and digital architecture and provided recommendations to optimize data gathering and operational efficiencies. We examined current and future physical and digital site connections and developed a cohesive strategy to manage all implemented systems throughout the development as well as the inclusion of outside civic and government information sources. The masterplan also includes best practices for developing and maintaining integrated local building, operations, and data systems and for providing a foundation for future technological innovation for all development stakeholders.



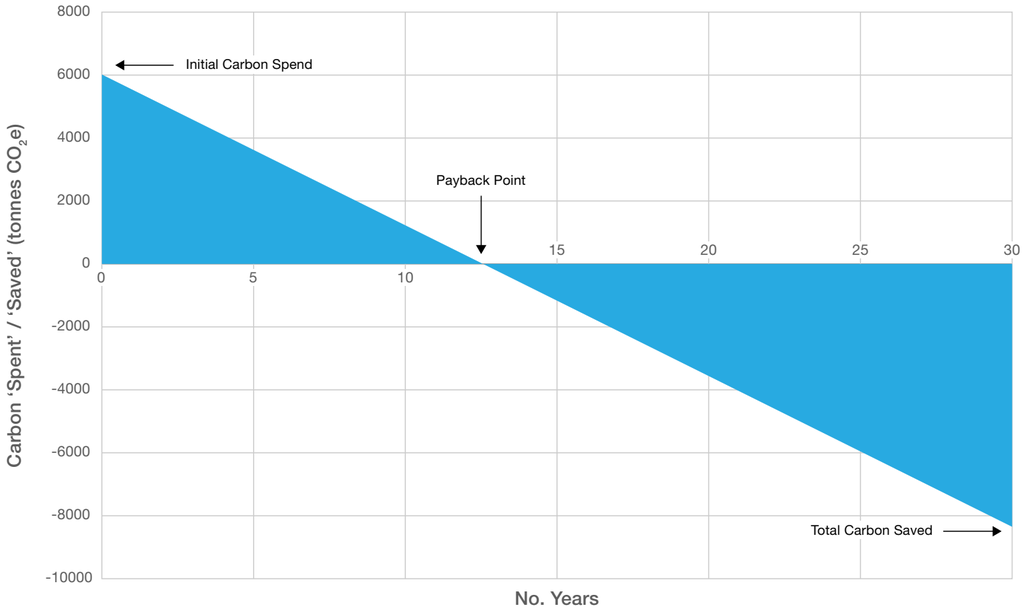
Guy’s Hospital Tower Wing
London Bridge, UK

How do you refurbish a fully-operational hospital tower with a deteriorating facade to address tenant wellbeing and embodied carbon concerns on a tight budget?

At a glance

Guy’s Hospital Tower Wing in London Bridge was reclad with profiled metal rainscreen panels, additional insulation, and double-glazed windows to address much-needed improvements in energy efficiency, occupant thermal and visual comfort, and envelope heat gains/losses, all while the hospital remained fully operational.

An embodied and operational carbon assessment revealed the payback period to be less than 13 years, with a 7.6% overall reduction in energy use achieved purely through the refurbishment of the building envelope.



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Harvard University Smith Campus Center
Cambridge, MA

How do you transform a dated corridor lobby into a vibrant university gateway and nexus?

At a glance

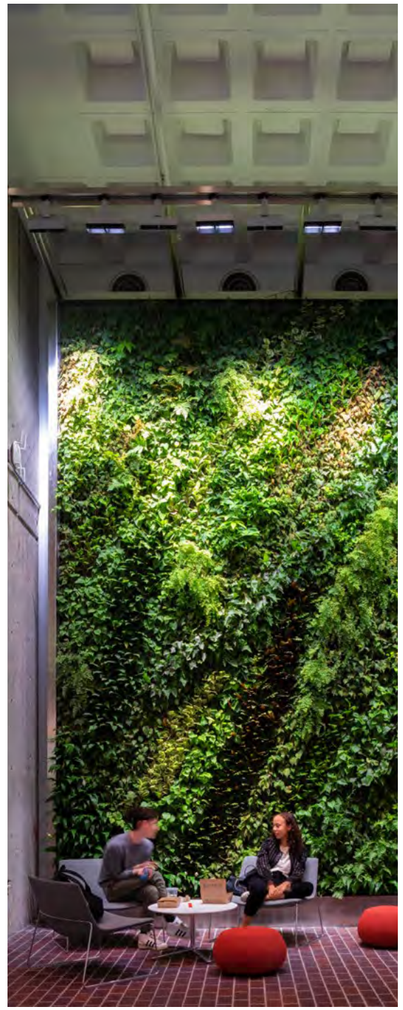
“I’ll meet you at the concrete building next to the Out of Town News stand” is how many people would make arrangements to meet at a location that should have been known as the gateway into Harvard University. The “concrete building,” if mentioned at all, is a modernist icon designed by Sert constructed in the 1960s. A narrow lobby housed various retail shops and eateries with administrative offices in twin high-rise towers above, utilized more often as a brief place to stop off and mainly a transient space.

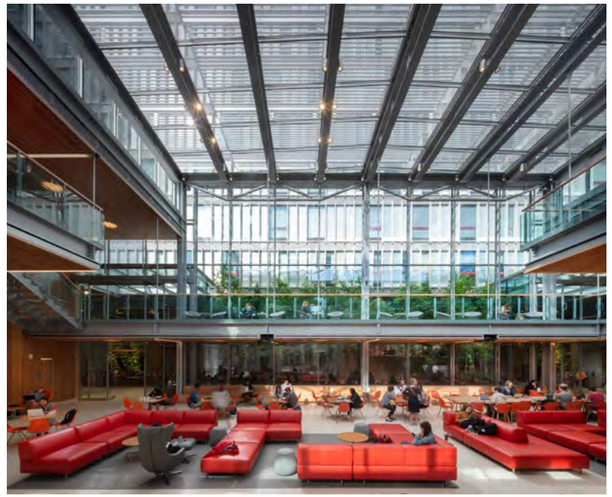
A new nexus

Selective replacement and retrofit of ground- and second-level spaces around the high-rise towers creates a reinvigorated flexible student gathering space with open views and intersection with natural elements via green walls, roof top terraces, and a showcase ground level vitrine with trees open to the air above, engaging wildlife. A sense of peaceful quiet is so prevalent in the Holyoke student pavilion that the keynote speaker praised the acoustics of the space, enabled by Arup mechanical design.

Top tier views

Within the high rises above, new office and meeting spaces are created with associated retrofits at the 9th and 10th floors. Tight interweaving of MEP within existing structural boundaries opens up bright board conference rooms to the best views of surrounding Cambridge and Boston beyond.





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John Ferraro Building Sustainable Modernization Assessment
Los Angeles, CA

How do you transform an historic landmark into a sustainable, modern showpiece?

At a glance

The Los Angeles Department of Water and Power (LADWP) has called the John Ferraro Building (JFB) its main headquarters since 1965. LADWP recognized that they needed both an understanding of what they would need to upgrade, as well as a strategic vision for transforming JFB to become a leading example of building sustainability, energy efficiency, water conservation, and seismic resilience. LADWP engaged Arup to provide energy/sustainability, facades, structural, mechanical, electrical, plumbing, fire/life safety, and civil services, along with a range of subconsultants, including architecture and cost estimating, to produce a Sustainable Modernization Assessment.

Interdisciplinary focus on efficiency

The catalyst for the assessment was improving the energy and water efficiency of JFB as part of an overall retrofit capital planning process. Arup's mechanical, electrical and plumbing teams collaborated closely with the Arup facades and energy/sustainability teams, as well as with the historical preservation and environmental consultants to recommend forward-thinking solutions that could be implemented given the existing conditions.

Using the past to look forward on seismic resilience

Arup reviewed as-built drawings, calculations, prior seismic assessments, and site seismic hazard data to complete an ASCE 41 Tier 1 non-structural element survey of the building and a Tier 3 structural assessment of the building. The Tier 3 assessment included a linear-elastic 3-D model to estimate the building structure's behavior under multiple seismic hazard conditions. With an understanding that today's codes and standards are more stringent than those JFB was developed under, LADWP asked Arup to provide four seismic resilience retrofit recommendations for consideration.

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Judicial Council of California Seismic Renovation Study
Various Locations, CA

How do you prioritize the mitigation of seismically vulnerable buildings across the state of California?

At a glance

Arup is leading the seismic evaluation of 27 high-risk court buildings across the State of California. The study includes developing several conceptual retrofit schemes and associated construction costs for each court building.

The reduction in seismic risk for each retrofit scheme is quantified in terms of casualties, downtime, and repair costs using a fully probabilistic approach. Cost-benefit analysis is performed to identify optimal retrofit options and help prioritize investment strategies across the portfolio.

Our services

- Site inspection and seismic evaluation of 27 court buildings using ASCE 41 procedures
- Design of conceptual retrofit schemes to support cost estimation
- Development of probabilistic risk models to predict casualties, downtime, and repair costs in various earthquake scenarios
- Cost-benefit analysis to determine optimal retrofit options and inform client decision-making

Our value add

- Ability to manage large amounts of data through custom project website
- Ability to interpret and effectively communicate technical findings to support client decision-making

"My team was impressed with the amount of data catalogued, the seismic analysis work, and the project website."

Clifford Ham, Architectural Program Lead, Judicial Council of California

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Kimbell Art Museum
Fort Worth, TX

How do you modernize museum infrastructure while preserving the architectural aesthetic?

At a glance

Arup worked with the Kimbell Operations Team to develop a masterplan to renew the Kimbell Art Museum's aging MEP infrastructure systems. The iconic, Louis Kahn building dates back to 1972. Arup went on to design and lead the implementation of the full masterplan, which efficiently maintains the world-class museum environmental conditions required to preserve the Kimbell's priceless collections, while improving resilience and providing the flexibility needed to accommodate future traveling collections.

Resilient, efficient, and safe

Key modernization efforts included the installation of a 600kW generator to protect the art collection during long-term power outages; upgrades to the air-handling units to provide efficient and redundant fan wall systems, upgrades to cooling tower to provide high-efficiency cooling tower fill (doubling tower capacity), the addition of UV lights; and lighting upgrades to provide LED fixtures with Bluetooth adjustment capability. These changes have provided critical redundancy, reduced energy costs by over 20%, and improved the health and safety of staff.

Phased modernization

The phased masterplan was designed to minimize the impact on museum operations. Each phase had a capital budget and the most fragile and critical mechanical, electrical, lighting, and controls systems were replaced first, thereby incrementally improving performance, reducing risk, and setting up the next phase for success.

Protecting iconic architecture

Arup implemented creative, interdisciplinary solutions to ensure that the aesthetic of the Kahn Building was not impacted. Arup specialists worked through extensive details, including retooling the lighting manufacturer's factory to enable them replicate the look of the original Louis Kahn lighting fixtures, while safely reducing the wire quantity and minimizing the associated fire risk in existing conduits. Arup also devised a strategy to conceal the generator in an acoustical concrete structure veiled by existing shrubbery, mitigating both aesthetic and acoustic impacts. Similarly, Arup's cooling tower upgrades allowed the original tower skin to remain untouched and unchanged, as it was part of Louis Kahn's original design.

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King’s Cross Central Development, Coal Drops Yard
London, UK

How do you transform derelict industrial yards into a new shopping district for London?

At a glance

At Coal Drops Yard in King’s Cross, Arup helped turn three largely derelict heritage buildings into a popular shopping and dining district.

An expansive new upper level with a sculpted roof unites the whole, while bridges provide additional links. Victorian brick viaducts are now home to modern retail brands and restaurants, with space in between for events, art installations, and markets. Vestiges of the past are everywhere.

Building on our heritage

Built in the 1800s for distribution of coal, much of Coal Drops Yard had lain derelict for years, becoming severely overgrown by vegetation. In the 1980s, a large area was gutted by a fire, destroying or damaging the original timber structure; the few cast iron beams and columns that survived were in unknown condition. Another area hosted some of London’s most iconic nightclubs, with the structural fabric painted black or hidden behind plasterboard.

Collaborating to transform and reuse

Arup worked in partnership with the project team, local authority, and Historic England, via workshops, meetings, and site visits. Together, we refined and engineered the design to retain as much of the existing structure as possible, while upgrading building performance.

Minimizing risk by building insights

In the absence of structural information on the original construction, it was vital to build understanding of the site’s structural capacity and condition to make it possible to retain the Victorian architecture. Through Arup’s knowledge of construction history, and by uncovering evidence relating to the site and working closely with the heritage architect, Giles Quarme Associates, we established an archaeological understanding of each phase of development.

Innovating to solve challenges

We established early on that the existing structure had limited capacity for additional loads. So we made the structure for the new upper level and roof independent from the existing structure. Instead, they are supported on steel and concrete framing, threaded through the original buildings and founded on new mini-piles squeezed within internal bays.

The upper level is enclosed in a tapering 8m tall structural glass façade. This spans vertically between the slabs and trusses, relying purely on the glass panels arranged in a folded geometry. The system is bonded with structural silicone to increase the stiffness and load-bearing capacity of the façades. The sculpted roof has a 32m clear span and supports a suspended floor via steel hangers.

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ARUP

King Street Station Restoration
Seattle, WA

How do you modernize a station built in the 1900s?

At a glance

Seattle's railway hub station for Amtrak and Sounder traffic was constructed in 1906 in the Pioneer Square Historic District and underwent its first major seismic upgrade in 2012. Working under the guidelines of ASCE41, a new seismic rehabilitation code geared toward performance-based design, Arup crafted economical solutions to protect as many of the building's historic architectural features as possible, including the use of steel plate shear walls to reinforce the brick façade and exploiting the effects of the liquefiable soils beneath the building.

Reinforced façade

Thanks to ASCE41, Arup's engineers were also able to take a novel and cost-effective approach to reinforcing the building's brick façade. Concrete is often used in a seismic upgrade of this nature, but using concrete on this project would have required demolishing much of the building's historic plasterwork. Instead, the engineers opted to use steel plate shear walls—an equally effective method that eliminated the need for a great deal of costly foundation work.

Cost savings

Arup helped cut project costs in two other important ways. Using ground-penetrating radar and several other exploratory techniques, the design team was able to prove that the existing wood piles went through the unstable liquefiable soils to good bearing, thus negating the need for extensive new piling. Using a variety of time-saving analysis methods, Arup was also able to shave four to six months off the project's peer review process.

LEED Platinum

Arup's MEP engineers also played a pivotal role in putting the King Street Renovation to achieve LEED Platinum. The project utilizes a geothermal well field and ground source heat pump technology to heat and cool the building more efficiently and reduce energy costs. Rather than using massive new HVAC systems to keep the building at a constant ambient temperature, Arup's engineers have proposed the idea of using natural ventilation and localized heating solutions to achieve original temperature comfort criteria.

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LAX RS-X Receiving Station signage Los Angeles, CA

At a glance

Arup is providing code-required signage and wayfinding for the new Los Angeles Department of Water and Power's (LADWP) receiving Station and project site. The plan addresses building and site identification signage, ADA and Title 24 room and bathroom identification signage, and egress evacuation signage. Equipment specific regulatory signage is being provided by LADWP.

Arup employed the Los Angeles World Airport (LAWA) wayfinding and tenant guidelines, in addition to designing new sign types to satisfy code requirements when standards did not address site specific signage needs.

New sign types are informed by the spirit of LAWA guidelines in terms of materials, sizes, colors, and fonts and existing, similar conditions for signage currently in use at the airport. This project is subject to the approval of the Los Angeles Cultural Affairs Commission, a mayor-appointed advisory board responsible for the review and approval of all architecture and artwork on, or over, City property.

As part of a broad suite of services offered, Arup developed code required signage and wayfinding for a new service building at LAX.

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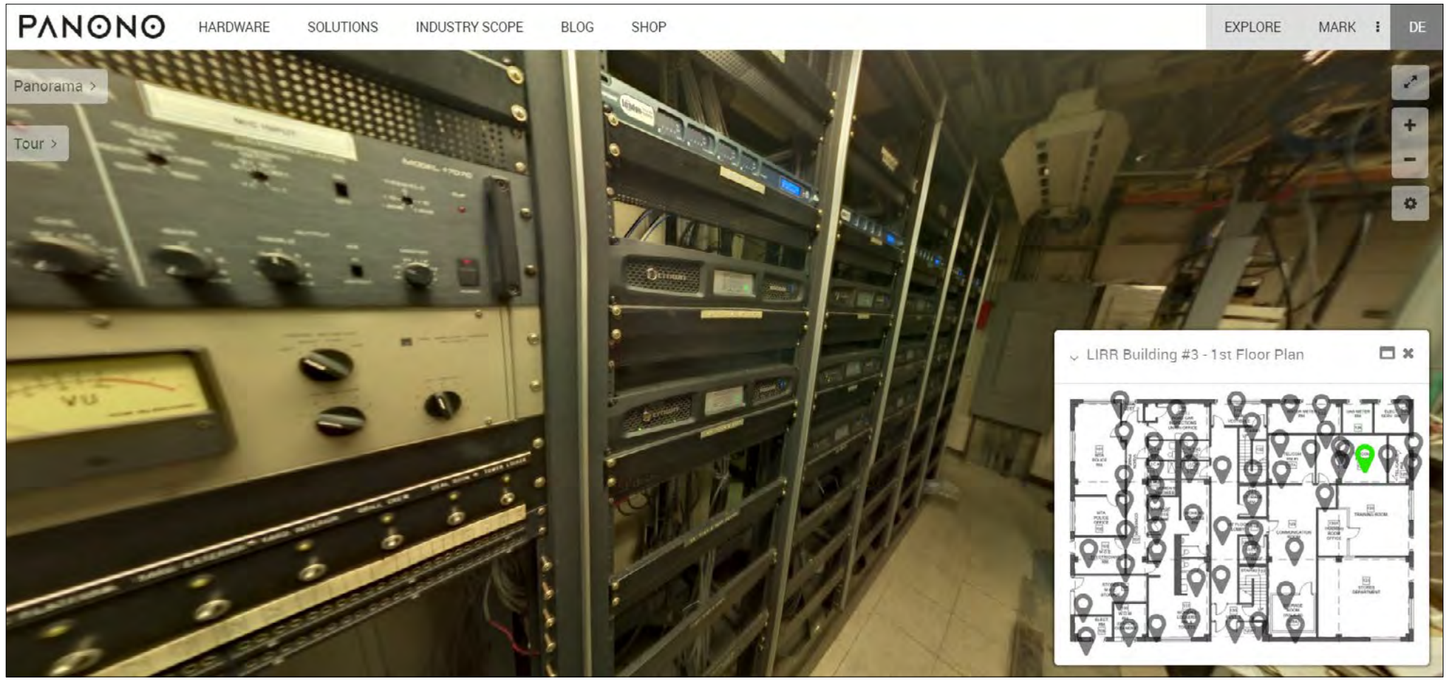
Long Island Railroad offices
New York, NY

Looking to decommission their buildings to make way for the Hudson Yards development, Related Development asked Arup for a LiDAR scan of the office spaces so they could replicate the LIRR's facilities at a new location. We embarked on further discussions with the client to determine if dimensionally accurate 3D data was required in this instance and a full LiDAR scan was ultimately deemed unnecessary. Instead, we created a set of online, 360-degree virtual tours that met the client's needs while also saving them 90% of the costs and time associated with a LiDAR scan.



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Los Angeles Memorial Coliseum
Los Angeles, CA

How do you modernize a historic landmark while preserving its legacy?

At a glance

For almost a century, the Los Angeles Memorial Coliseum has served generations of Angelenos, from countless football and soccer games to concerts and public appearances by US presidents and international dignitaries, such as Martin Luther King, Jr., the Dalai Lama, and Nelson Mandela. Since its opening in 1923, the stadium has welcomed more than 118 million visitors and hosted more than 4,500 events. As the only venue to hold two Summer Olympics, and soon a third in 2028, the stadium carries an iconic legacy that must be considered when outfitting it for the future.

Arup worked closely with the University of Southern California and DLR Group to modernize the Los Angeles Memorial Coliseum and provide exceptional fan experiences through upgraded amenities and improved services. The Arup design team provided high-speed Wi-Fi coverage and premium seating while maintaining the stadium's historic façade and character.

A new tower

The LA Memorial Coliseum's new seven-story Scholarship Club Tower will provide patrons with an improved experience, including 360-degree views of Los Angeles, new suites, a press box, exceptional food and beverage amenities, and premium seating.

Providing better coverage and connectivity

While Wi-Fi and cellular coverage are key components of sporting venues, college stadiums typically do not feature reliable service. Arup's project team aimed to provide an exceptional wireless and cellular experience for patrons but encountered several challenges that spurred innovative solutions.

Preparing the stadium for the future

The wireless and cellular infrastructure is built for current technology but is scalable when new technology becomes available. Due to the rapid development of technology and its shortening life cycle, it is important to provide flexibility for future upgrades.

Renovation

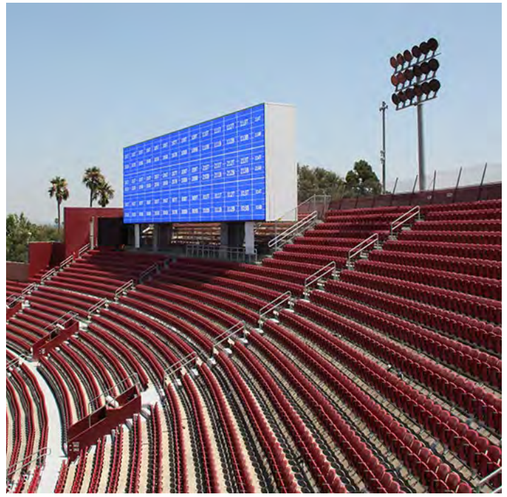
$315 million

Stadium

27 acre

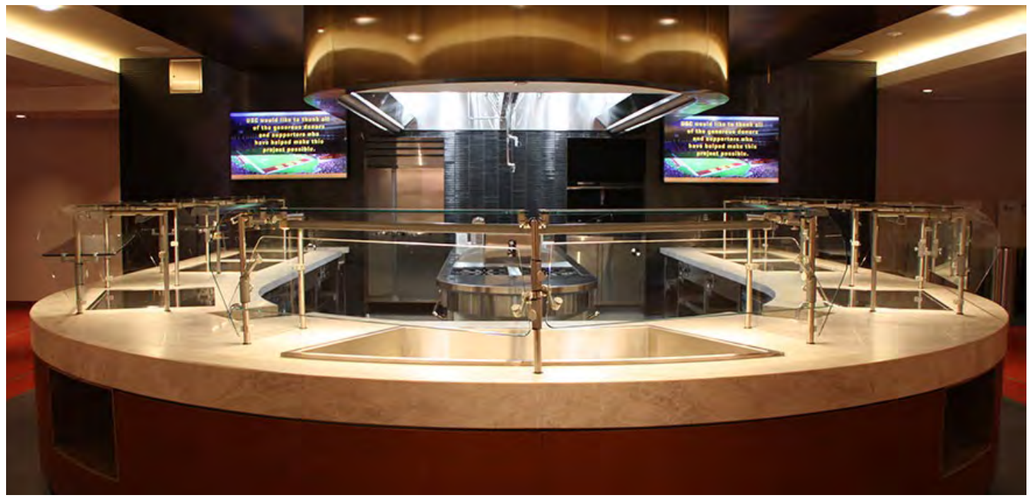
New Scholarship Tower

231,340ft²



"This project speaks to Arup's DNA because we enjoy taking on complex projects with an intent to find creative solutions. While the stadium's landmark status posed unique restrictions and challenges, working with our partners, we are proud to bring the stadium to the 21st century and honor its legacy. "

Elizabeth Valmont, Associate Principal and Project Manager



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MASS MoCA Building 6
North Adams, MA

How do you transform a turn-of-the-century industrial manufacturing building into a showcase for modern art?

At a glance

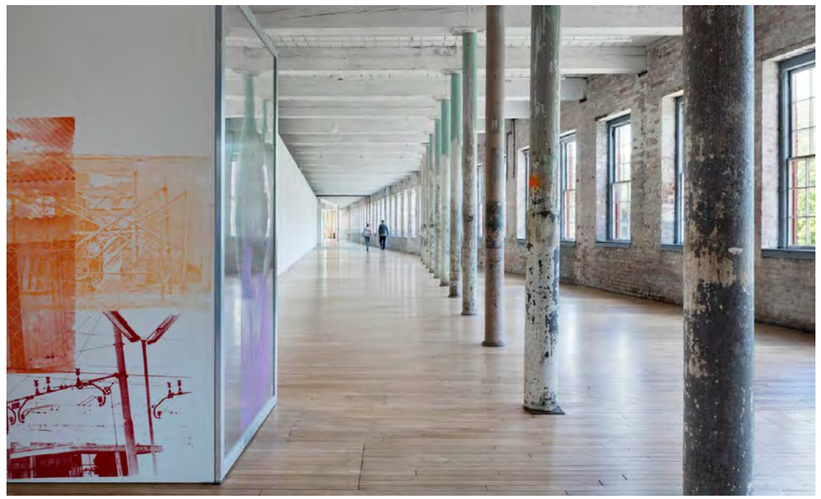
The MASS MoCA museum is a campus of interconnected brick and timber industrial buildings constructed in the early 1900s. One of the largest (Building 6, consisting of 3 floors at 40,000ft² each) had mainly served as underutilized storage and workshop space. The museum wanted to revitalize the campus by activating the entire building as vibrant new exhibit and function space.

New spaces, light and lighter

Several new double-height spaces were created to allow more light and views into the building, as well as to house a new immersive exhibit by James Turrell.

The building is a quilt on display

The existing mill building is a palette of old brick bearing walls, cast iron columns at ground level, with a patchwork mix of wood, brick arch, and concrete infill floors over a crawlspace basement, which used to allow underground run off from textile manufacturing directly into the surrounding river (a practice, thankfully, long since stopped). Old timber columns, beams, and decking create the upper floors and roof. Bringing a historic building formerly relying on pure weight for overall stability up to modern lateral code standards for resilient ductility required a creative stitching of steel woven in various ways throughout: braces, ties, struts, window frame portals, all anchoring down to new or reinforcing foundations



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MTA Enhanced Stations Initiative
New York, NY

How do you upgrade a network of over 450 aging metro stations with minimal disruption to users while providing maximum value?

At a glance

The program included the design of enhancements for 31 NYC Subway Stations throughout the five boroughs. The primary drivers for the program were, cost, schedule, and technical excellence. All three were managed through the design build project procurement and delivery process.

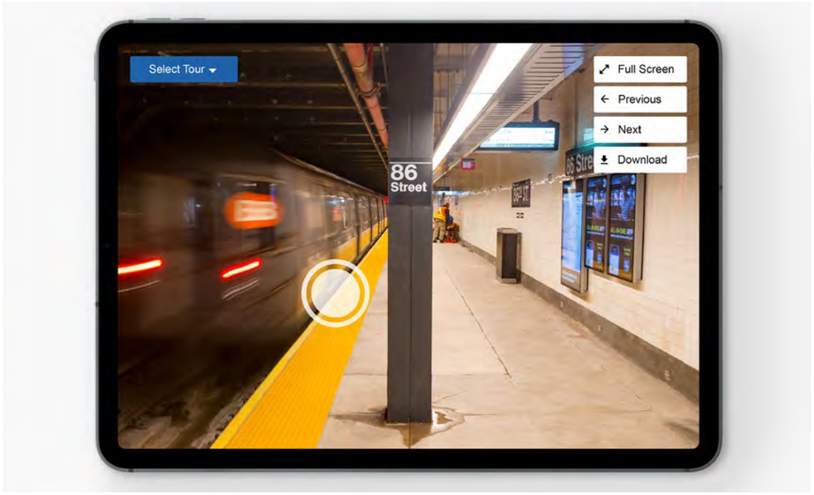
A wealth of digital information was collected, indexed, and made available for potential bidders, reducing risk in the bids, and cutting the time required for tender design preparation and final design and construction.

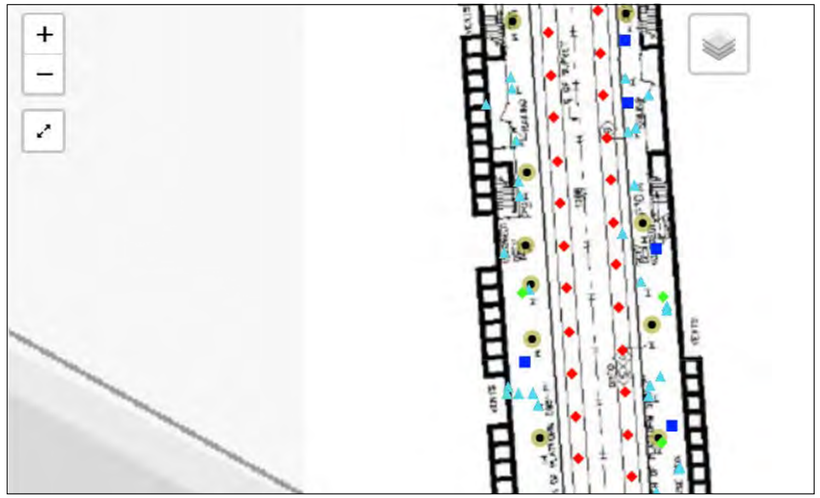
Arup designed a bespoke digital dashboard to help manage the complex program that enabled the collection and management of:

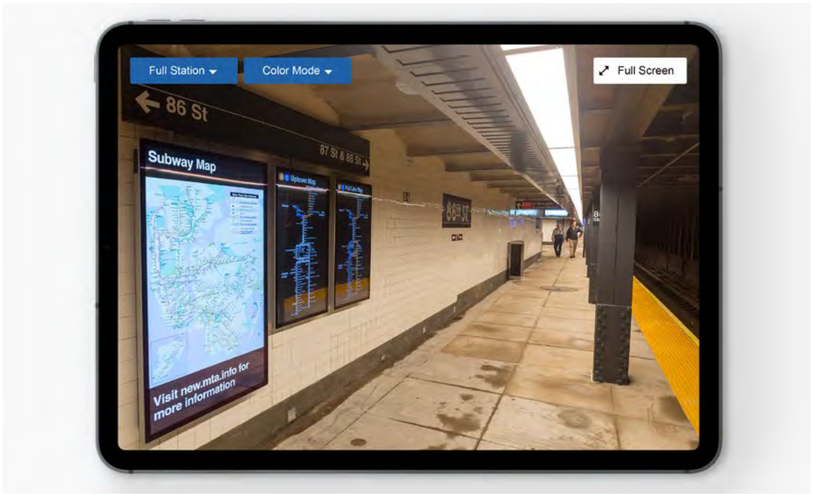
- Record drawings
- Geotagged site observations
- LiDAR scan/survey data
- Program schedule
- 360° Photography

The dashboard helped the team:

- Reduce risk for design build contractor bids
- Reduce the time required for tender and final design
- Increase clarity around program assets and project Scope







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New Scotland Yard
London, UK

How do you transform a neoclassical 1930s building to be the headquarters for the Metropolitan Police Service?

At a glance

The 1930s Curtis Green building on Victoria Embankment holds special heritage interest, a prominent position on the Thames, close to the palace of Westminster, and it sits within the Whitehall Conservation area. The decision to relocate the headquarters to Curtis Green also provides an opportunity to rejuvenate the immediate environment on Victoria Embankment. This includes restructuring the landscape to improve public access to the adjacent Whitehall Gardens. We are also creating a street-level pavilion in the front of the building that will provide a welcoming space for visitors.

Maximizing space

The design team has sought to create a multifunctional office space, placing the needs of the office staff and visitors at the center of the design process. Our design encourages greater interconnectivity between departments and more opportunities for interaction among its staff. Maximizing the building's usable area has been a focus for our structural and building services engineers. The existing floor area has been increased from 4,700m² to 6,400m² while maximizing floor-to-ceiling heights.

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ARUP

Portfolio assessment
Confidential client, CA

At a glance

Arup collaborated with a confidential client on the development of a bespoke framework to comprehensively assess their existing project portfolio and aid in making strategic investment decisions.

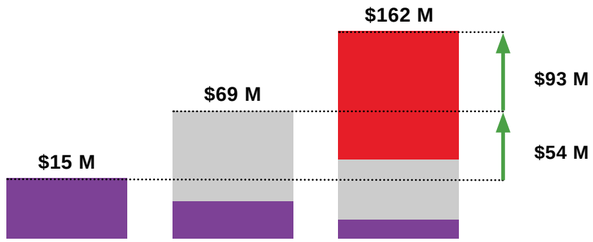
This framework was trialed on the assessments of two large-scale 1970s-era office buildings. Arup was tasked with completing multidisciplinary condition assessments for both buildings, as well as leading the project management,and costing of detailed improvement scenarios. Recommendations were designed to complement existing maintenance regimens and planned campus developments.

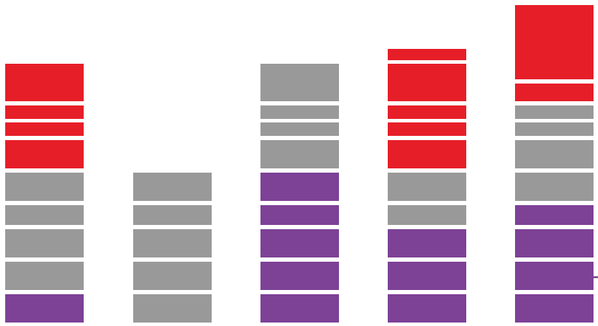
The framework grouped all potential building investments into three categories:

Baseline improvements
Where the buildings continue to be refreshed and reactively maintained.

Selective remodel
Where the major renovation and remodeling of interior spaces coupled with strategic façade improvements will help extend the buildings life as well as improve its environment for its occupants.

Major renovation
Where the buildings receive completely renovated interior spaces and major modifications to the core and shell space to further extend useful life and offer dramatic improvements in occupancy standards for its tenants.





The framework offered a clear opportunity to understand the costs, benefits and downsides with each tier of upgrade. This included $15m for baseline improvements, $69m for selective remodel, and $162m in major renovations.

Localized Repairs to Deck and Roof Membranes

Brittle waterproofing at area drains with moisture beneath

Example action and photo from condition assessment.

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Print Building
San Antonio, TX

How do you add stories to an old building and transform it into a modern retail and office space?

At a glance

Local developer GrayStreet Partners purchased the former San Antonio Light newspaper headquarters, which included a 1931 Spanish Colonial Revival structure and the adjacent Print Building, with the goal of transforming the structures into 140,000ft² of retail and Class A office space. Working with design architect Gensler, Arup's structural team helped the owner add three new floors on top of the existing Print building, making the project financially feasible.

Making the best use of an existing structure

The challenge in adding new floors was finding a way to avoid costly foundation reinforcements and structural strengthening. To accomplish this, we first did a through investigation of the capacity of the existing foundation and structure, and then used light-weight concrete on metal deck and composite steel for the new floors to minimize weight. To make the combined structure stronger to resist lateral loads, we tied the two reinforced concrete structures – built in 1962 and 1967 respectively – together.

Existing columns and existing roof

The existing columns were strengthened by enlarging the cross section. This was executed by the developer's crew, after we performed tests on a few columns to ascertain production efficiency. The existing concrete roof was reinforced by adding new topping integral to it, making the existing structure deeper, and achieving adequate strength and stiffness.

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Roy and Edna Disney California Arts Theater (REDCAT)
Los Angeles, CA

At a glance

To help kickoff their new Inside Out & Upside Down: Posters from CalArts 1970-2019 exhibit during the COVID-19 shutdown, REDCAT commissioned Arup to create an interactive, photo-realistic model of their gallery for easy online viewing. We captured the space using a Matterport Pro 2 scanner and then worked with the gallery to attach information and media to specified places within the exhibit.

The client website continues to proudly display this digital museum experience, which also contains a built-in VR viewer for guests using smartphones and VR headsets. While it is no substitute for actually being in the gallery, we've provided both REDCAT and its virtual guests a way to experience the art from the safety of their homes.

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San Antonio Museum of Art
San Antonio, TX

How do you lower the operating costs of a museum?

At a glance

Arup was engaged by the San Antonio Art Museum to develop a masterplan for the creation of a new central utility plant to serve the museum campus. Working within a budget of $6.4m in raised funds, Arup responded to the challenge by viewing the problem from a different perspective. Arup's renovation to the museum provided energy efficiency to reduce operational cost, improve resilience, and increase comfort inside the building.

Arup generated a masterplan driven by HVAC and building control upgrades that drastically reduced operating costs and substantially reduced the needed central plant capacity and capital cost. As a result, the museum is receiving a renewed infrastructure better adapted to preserving the environmental conditions of the art, while spending less on large central plant equipment. Arup acted as the prime consultant, leading a team of architects and civil engineers to design and oversee the construction of the new central plant project and the HVAC systems renovation.

Arup designed the new central heating, cooling, and emergency power plant, modified the heating system to provided hot water, and improved the museum's air condition quality.

The project was performed without interrupting the operations in the existing building.

The San Antonio Museum of Art's primary priority is the preservation of their artifacts. This maintenance required a central utility plant and HVAC renovation to improve reliability and energy efficiency.

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Seismic Risk Assessment
Global Portfolio

How do you consistently assess the seismic safety of a global portfolio of 400+ properties?

At a glance

Arup has performed a number of seismic assessments of large international portfolios of buildings for a global financial institutions. In these projects we applied mobile technologies at a global scale to collect and analyze a broad range of data to assist our clients in managing their seismic risk.

Global reach

The projects involved the assessment a wide range of building types across all regions of the world ranging from retail branches to data centers and corporate offices. Arup deployed staff from offices across the world – including North America, Asia, Australasia, and Europe – to deliver assessments to informed by local knowledge to the clients

Digital data collection for consistent reporting

Arup developed custom solutions powered by mobile technologies to enable engineers to rapidly collect data and generate reports in the field. This allowed the team in one instance to assess a total building area of more than 8 million square feet across approximately 400 buildings in the space of four months. Further, consistent data at a global scale allowed the team to identify trends across the portfolio and prioritize further work to focus on areas of greatest risk.

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Smith College, Cutter and Ziskind Dormitory Northampton, MA

How do you transform a dated modernist dormitory into a campus living community?

At a glance

In collaboration with Perkins + Will, Arup renovated Smith College's Cutter and Ziskind residence halls. Originally built by Skidmore, Owings, and Merrill in 1957 and 1955, respectively, the two housing units encompass 68,500ft² and are connected by a dining hall and a kitchen. The renovation centers on two main factors: a desire to adhere to architectural tradition and a need to explore better sustainability options. Arup's wide range of experience in both sustainability and preservation allows for renovations increasing the buildings' efficiency while still maintaining the integrity of the original mid-century architecture.

Fully transformed

Based on conditions assessments and code analyses, the renovation includes replacing or modifying all major systems and building components, in addition to updating interiors and improving energy efficiency. The renovation incorporates green technology and sustainable building practices.

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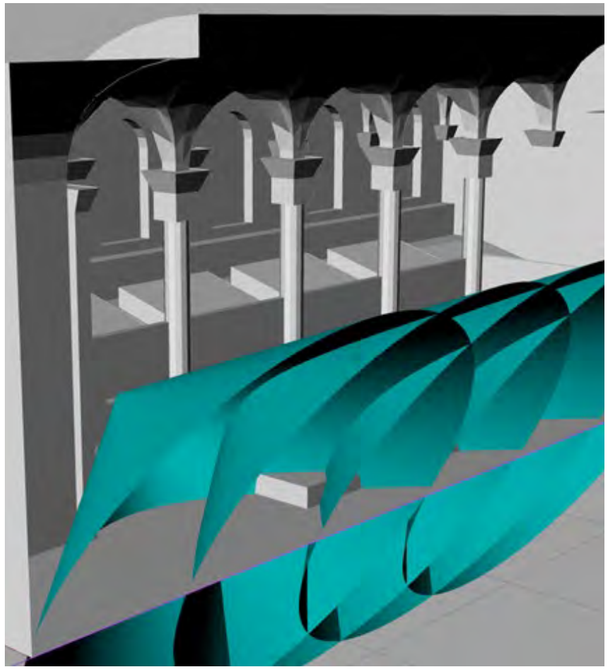
St Paul’s Chapel
New York, NY

St Paul's Chapel, New York's oldest standing church, is notable for having served as a house of worship for President George Washington and a place of refuge during the 9/11 attacks on the World Trade Center. Now a museum, the landmarked cultural site must preserve its history while meeting the standards of a contemporary building. Arup was originally contracted to help plan technology renovations for the museum and ultimately offered to perform a 3D scan to enhance our AV and security designs.

By using 3D geometry to analyze sound resonance and visualize the potential coverage of panoramic CCTV cameras, Arup was able to develop designs that met the client’s requirements while reducing any disturbance to the architecture. We were then asked to scan other properties for the client, Trinity Real Estate.



Television Centre
London, UK

How do you transform the BBC's former headquarters into a vibrant new hub for London?

At a glance

Television Centre is one of London's most ambitious redevelopment projects. It turns an iconic 1960s building and 30-acre site into a 1,700,000ft² neighborhood, with new homes, offices, television studios, restaurants, a cinema, and hotel. Appointed by Stanhope to provide an array of services, Arup's involvement spans from pre-purchase feasibility studies through to multidisciplinary design across the existing residential elements of the masterplan.

Building on our heritage

The new Television Centre honors the original design of the Grade II listed former BBC headquarters. The design team worked with the existing structure, exposing it and restoring heritage features, such as a mosaic mural by John Piper, floating cantilevered staircase, and ceramic tiling in the Helios Courtyard. Arup's team included heritage experts who worked closely with the architects, construction managers, and our building engineers to minimize any impacts on heritage features, including monitoring during construction. Combining reuse and new build projects, the first phase of Television Centre is now complete and the second phase under way.

Minimizing risk through digital doubles

Through building information modeling (BIM), Arup developed detailed 3-D models for each individual building, drawing on archive data and validating through targeted surveys. This empowered the diverse team, including architects and engineers, to model within the digital twin. This made effective collaboration and coordination much easier across the incredibly complex site and improved the accuracy of cost and program forecasting, significantly reducing risk.

Collaborating to maximize value

We worked collaboratively with masterplan architect Allford Hall Monaghan Morris and multiple other architects for individual buildings to maximize value. This included helping increase rental values across 550,000ft² of new office space by creating a lean floor sandwich. Building services are exposed, contributing to an aesthetic with appeal for creative and media industries.

Contributing to our low-carbon future

We investigated conditions across the site, including reuse of existing foundations to minimize embodied carbon and environmental impact, which led to the development of a low-energy design, reducing environmental impacts, construction costs, and long-term running costs. Individual buildings seamlessly plug into the site-wide infrastructure. The site also connects with local transport infrastructure, parkland, and facilities, for a low-carbon and wellbeing-focused world.

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TWA Flight Center Hotel, JFK Airport
Jamaica, NY

How do you transform a landmark aviation terminal into a world-class hotel?

At a glance

The TWA Flight Center originally opened in 1962 and served as TWA's terminal at JFK International Airport until 2001, when it was no longer able to support modern aircrafts. Arup worked with developer MCR and architects Beyer Blinder Belle and Lubrano Ciavarra Architects to transform Eero Saarinen's landmark flight terminal into a one-of-a-kind New York destination.

Sensitive restoration

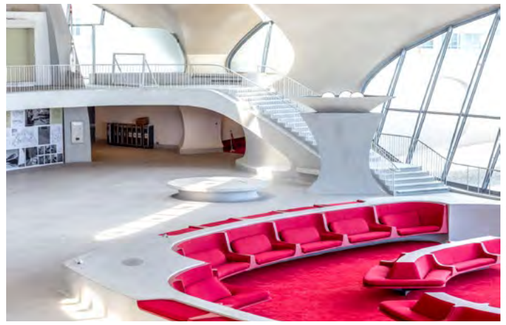
The restoration of the terminal's historic structure necessitated the removal of various exterior additions made over the years and the restoration of several areas of concrete façade to match the existing. Arup adapted and reinforced areas within the existing structure to provide sweeping ramp access, complying with the Americans with Disabilities Act (ADA) standards and improving luggage transport.

Holistic integration

Arup's creative structural solutions allowed two new hotel room wings and a two-story, below-grade events space to be seamlessly woven into the original terminal's complex geometry. A 3D Revit model of the below-grade geometry was built and included thousands of inclined piles that supported the existing building structure. The model was used to coordinate with architectural and geotechnical disciplines, and to maximize developable below-grade space for the client.

Back to the drawing board

To ensure that all aspects of the restoration stayed faithful to the original design, Arup's structural team located a full set of Saarinen's original project drawings, housed at Yale University, and used them in combination with a point cloud scan of the site to develop a 3D Revit model that was used to coordinate with other team members throughout design and construction of the project.



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University of British Columbia Seismic and Resilience Study
Vancouver, BC, Canada

How can a university plan for resilience when at risk of a magnitude 9.0 earthquake?

At a glance

Since 2016, Arup has provided a wide range of consulting and advisory services to the University of British Columbia, Vancouver, to guide the university in understanding key seismic vulnerabilities and risks, and subsequently, develop mitigation strategies, plans, and guidance documents for improving the resilience of its buildings and core operations to earthquakes.

The study began with a desktop assessment to identify the hazards, and impacts of climate change, that pose the greatest risk to the campus. After identifying earthquakes as the top threat, Arup conducted a campus-wide seismic engineering risk assessment of its 330 buildings to identify those with the highest collapse risk. We also estimated financial losses and downtime across the building stock and campus utility systems to predict the impact of different earthquake scenarios on core campus operations (including teaching, research, and housing) and the student population. We developed preliminary mitigation strategies and performed cost-benefit analysis to identify the most cost-effective ones.

Using findings from these studies, we developed a holistic seismic resilience framework that establishes a campus-wide vision for recovery of core operations after a major earthquake and outlines a “roadmap to resilience” for achieving this vision over the next 30 years. As a part of this framework, we also developed resilience-based design guidance for retrofit of existing buildings and construction of new facilities that aim to minimize seismic damage and downtime.

Existing buildings on campus

328

Individual campus utilities

5

Students in Vancouver

55,887

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University of Massachusetts Boston Campus, MA

How do you transform a decaying concrete plaza into a reinvigorated campus quadrangle?

At a glance

The University of Massachusetts Boston campus was built largely in the 1970s consisting of several concrete buildings around a quadrangle, interconnected over a two-story parking podium structure. Decades of exposure to salt and moisture severely deteriorated the substructure levels and the plaza surface above, became an uninviting, cracked hardscape.

Balancing to support a new vision

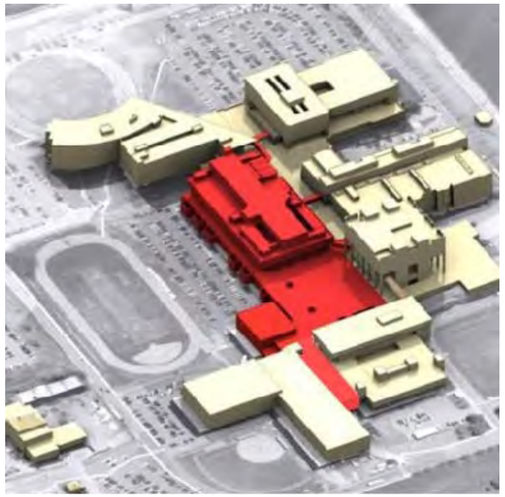
Tearing down a domineering, outmoded Science Building along with two stories of old parking structure in the quad and infilling back with recycled fill from demolition creates a new green quad. The weight of the new fill is carefully balanced against existing pile foundation capacities, utilizing a soil arch system developed by the geotechnical engineer. New entry interfaces to all the surrounding buildings are created at required elevations with accommodations for universal accessibility. A perimeter structural void corridor maintains pathways for utilities while cost effectively mitigating loads from heavy quad infill material that would down drag on existing building pile foundations.

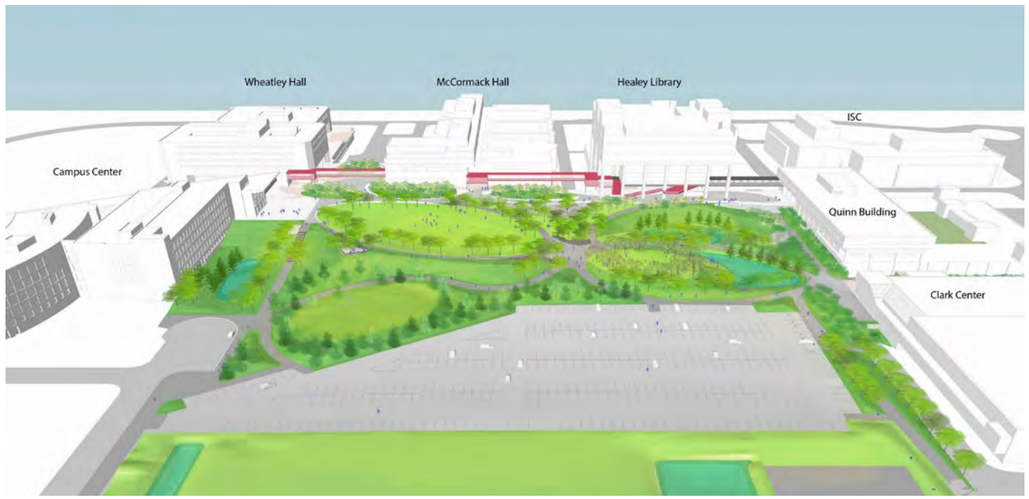
Cut, cap, and reconnect

Campus-wide MEP and Fire Protection services had to be judiciously demolished, untangled, and rerouted into a more recent campus-wide services renovation which put most of the infrastructure into a perimeter loop.

Safety above and below

New lighting throughout the quad, plaza perimeter of buildings, and new parking lot creates a welcoming environment for students and faculty, day or night. Deteriorated existing building substructures which could not be torn down due to undermining were re-stabilized to modern code requirements with targeted interventions appropriate for a change of use, eliminating underground parking and allowing more construction budget to be used towards people-oriented quad improvements.





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USC Stevens Hall Raulston Memorial Research Building
Los Angeles, CA

How do you renovate a building built in the 1950s to become a premier neuroscience lab?

At a glance

The Raulston Memorial Research Building at the University of Southern California Health Science Campus was renovated to house the Mark and Mary Stevens Neuroimaging and Informatics Institute. The project involves extensive renovation of a 1952 five-story concrete frame, brick facade building. Arup designed the building services for the 35,227ft² state-of-the-art laboratory that encompasses three MRI machines, a data center, a presentation theater, offices, conference rooms, multi-purpose collaboration areas and related support facilities.

Continuous processing

The neuroscience/informatics/genomics lab uses powerful supercomputers to analyze huge quantities of brain imaging, medical and genetic data to help understand such diseases as Alzheimer's and autism. One key challenge of the existing property was the lack of external space for a large generator that could provide backup power for the entire data center. Power loss could catastrophically disrupt data analysis procedures and require weeks-worth of reprocessing. Arup worked closely with the Institute's research and IT teams to develop an on-site battery, back-up cooling, and automatic power change-over systems that allow the servers to migrate critical processing to a limited number of operational racks.

Innovative integration

Close coordination between the Arup engineering team and SmithGroupJJR resulted in innovative integration solutions that allowed existing conditions to house cutting edge technology. Given the challenge of the building's low floor-to-floor heights, optimization of building services equipment sizing was essential. The mechanical design used an active chilled beams system to significantly reduce the amount of sheet metal ducting in the ceiling voids, which also reduced noise levels throughout the occupied spaces. The electrical design within the data center employed equipment top hats and cable tray to ensure future flexibility for power distribution and changes to IT connectivity.

Visualization for understanding

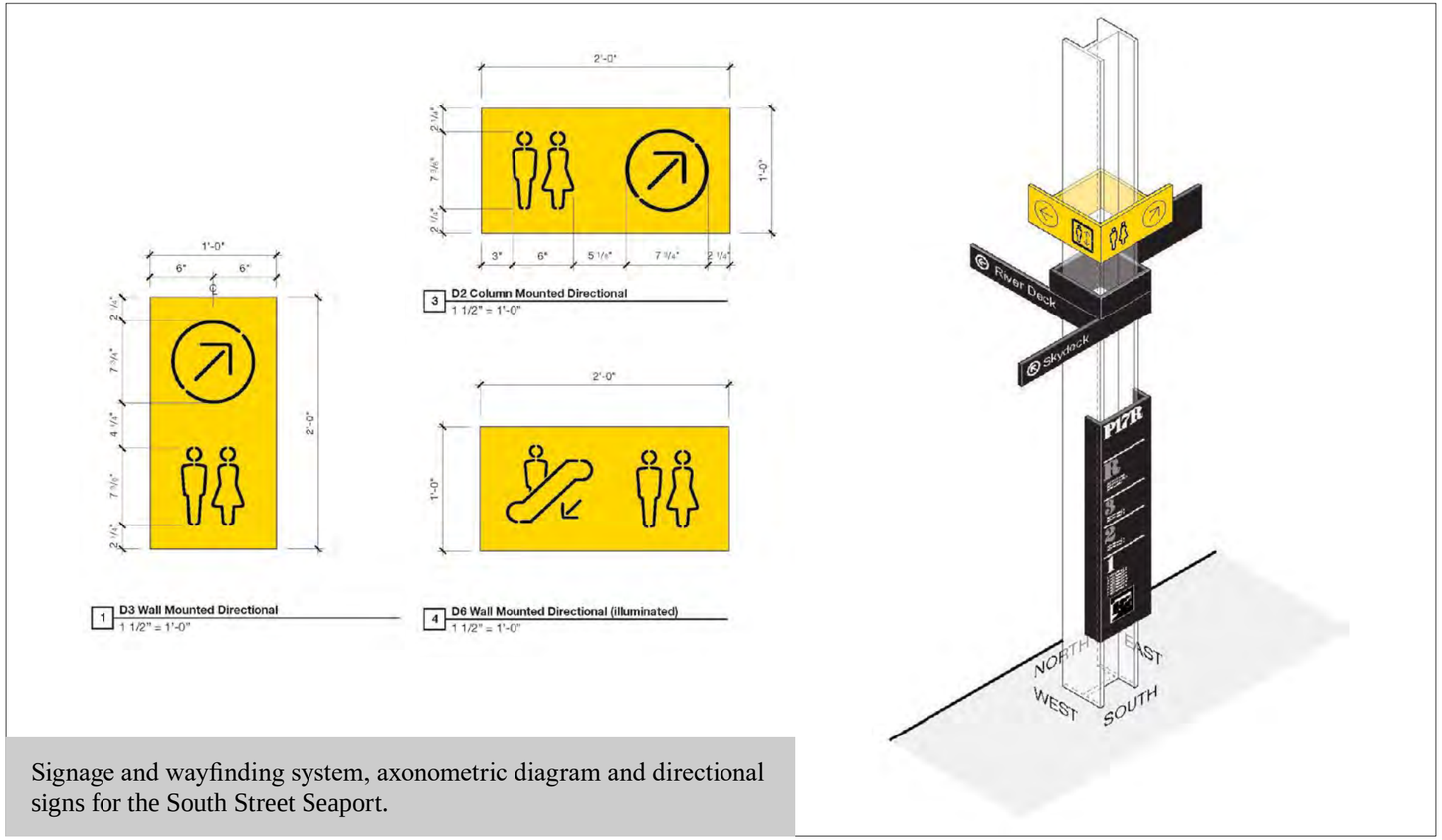
The central feature of the lab is the double-height Digital Immersive Visualization Environment, with its 18' tall x11' wide state of the art 4k Ultra high-definition LED screen. This room allows high definition images to be examined in person or shared with other research facilities in a presentation mode. Room acoustics were crafted to support broadcast, executive boardroom, teleconferencing, public lecture, and classroom functions.

Wayfinding for South Street Seaport New York, NY

At a glance

Located along lower Manhattan's East River, the historic South Street Seaport is a premiere downtown destination for visitors and locals alike. Pier 17, the project's centerpiece, anchors the development with premium retail and an expansive event space.

Arup devised a wayfinding strategy for the district to create a clear, effective, and consistent information experience. Arup's wayfinding approach is customer-oriented and focuses on improving the user experience across their entire journey. For Pier 17, Arup developed a signage design intent package to issue for bid and supported Howard Hughes during the bid process to select a fabricator. The team provided construction oversight for wayfinding, in collaboration with the sign fabricator (ColorEdge), architect (SHoP), construction manager (Hunter Roberts Construction Group) and owner (Howard Hughes).



Signage and wayfinding system, axonometric diagram and directional signs for the South Street Seaport.

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We shape a better world

Dedicated to sustainable development, the firm is a collective of 18,000 designers, advisors and experts working across 140 countries. Founded to be both humane and excellent, we collaborate with our clients and partners using imagination, technology and rigor to shape a better world.

Founded in 1946, Arup's unique trust ownership and enduring set of values work together to foster a spirit of intellectual independence and innovation through collaboration.

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